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METEOROLOGICAL VARIABLES AND THE NORTHWARD MOVEMENT OF NOCTURNAL LAND BIRD MIGRANTS

BY GILBERT S. RAYNOR

INTRODUCTION

AN investigation into the relationship between nocturnal land bird migration in the spring months and certain meteorological variables was begun early in 1953 at the Meteorology Group of the Brookhaven National Laboratory, Upton, Long Island, New York. Two variables, atmospheric stability and upper air wind direction, were believed on the basis of both logic and observation to be of major importance. The study was planned not only to evaluate the importance of these two factors, but also to reveal any correlation that might exist with other parameters. Owing to the scope of the program, which covered the United States east of the Rockies in area and the months of April and May in time, and owing to the large amount of data used, both meteorological and ornithological, it was necessary to confine the study to basic relationships and to classify the data into rather broad categories. Thus, individual species were not considered separately, but all nocturnal land bird migrants were grouped together. This grouping, however, is not believed to be artificial because years of observation have shown that a large variety of species commonly migrate through the same area on the same night, all of them apparently reacting to the same stimuli. Specific localities were not dealt with as such, but only as part of the whole area. However, each night was studied as a unit and the data later consolidated for the whole period.

MIGRATION PROBLEMS AND METEOROLOGY

For many years, ornithologists have noted what seemed to be relationships between the weather and bird migration, and many attempts to correlate the two have been made with varying success. Most of these attempts have had limited success owing to certain deficiencies in method or data. Few studies have been confined to one species

or one group of species that react to similar stimuli. Most studies have been too restricted either in time or in area to give a true picture of any class of migration as a whole, and until recently none have had enough data to use statistical methods. Most studies used only surface meteorological data and some only values obtained at the place of arrival. In spite of these drawbacks, a number of useful studies have been made and some light has been shed upon the problem by earlier investigators.

One of the earliest American ornithologists to call attention to a relationship between bird migration and the weather was Cooke (1888), who found the southerly winds in the warm sector of a low pressure area favorable for spring migration. In a later paper (1913), he concluded that birds prefer to migrate in spring with rising temperatures but that temperature alone is not a controlling factor. He found that surface wind direction was of little importance in spring migration. Eaton (1904) also found warm sector conditions favorable for spring migration whereas Smith (1917) found a relationship between spring arrivals and falling pressures. Main (1938) attributed the beginning of migratory flights particularly early in the season to warming temperatures.

More recently, Robbins (1949) showed a correlation between arrivals in the Washington region and above-normal temperatures, south or southwest winds, and low barometric pressure. Bagg and collaborators (1950) advanced the hypothesis that northward migration begins with falling pressures and southerly winds in the western portion of a high, increases in the warm sector of the following low, and is arrested by the arrival of the cold front from the west or upon arriving at a quasi-stationery front to the north. In an earlier paper, Bagg (1948) pointed out as a favorable condition for spring migration in the northeast a high pressure area moving off the southeastern coast of the United States and a low moving northeastward into the Great Lakes region.

Williams (1950) believed that nocturnal migrants cannot land safely in the darkness and that birds aloft overtaken by an approaching cold front might fly far off their course rather than alight in the darkness or attempt flight into the frontal area. He also suggested that birds might be carried far off course by the movement of the air mass in which they are flying if the skies are overcast and visual navigation is impossible. He observed that overhead migration ceases completely in spring when a strong wind is blowing, regardless of its direction. A study of the arrival of large waves in Minnesota in the spring of 1944 showed a correlation with high maximum temperatures.

Lowery (1951), by organizing telescopic observations of birds crossing the lunar disk and analyzing the data, has made the most significant contributions to our knowledge of nocturnal migration and certain of his conclusions may be briefly summarized. He concluded that nocturnal movements are not continuations of daytime movements, that until 11 P.M. or midnight, there is a progressive increase in the number of birds taking wing and that a gradual decrease takes place after that time. He found that nearly all nocturnal migrants come to earth well before dawn, that migrants are rather evenly spaced throughout the sky and that topography is apparently not important in governing flight densities. He also found that migration usually follows the prevailing air flow, that maximum migration occurs in regions of high barometric pressure, and that the passage of a cold front storm may almost halt migration in spring.

Although this method of study has proven more fruitful than any previously used, certain inherent limitations restrict its more extensive use and the confidence that may be placed in the results obtained. Chief of these is its confinement to the few moonlight nights during the migration season. The question also arises whether moonlight itself has an influence upon nocturnal migration. In addition, a moonlight night implies mostly clear weather, and conclusions drawn from observations made under any one type of weather condition can not be extrapolated to include other weather conditions.

Since previous investigations tend to show that the external stimuli which control or influence the day-to-day movements of migrants are largely meteorological, a large number of observations of actual migration should show a high degree of correlation with those variables that are actually of importance. The fact that different groups of birds respond to different stimuli makes it necessary to confine a study of this type to one homogeneous group. Soaring birds, for instance, depend largely on ascending air currents to keep them aloft, and it is obvious that areas or times lacking such updrafts would be unfavorable for extended migratory flights. Soaring birds normally migrate either on sunny days when thermal updrafts are present or along mountain ranges, coast lines, or other terrain features which cause mechanical lifting of the air.

Likewise those species such as the swallows and swifts which migrate by day and feed as they fly should favor days when considerable vertical motion is present. Glick (1939) has shown a good correlation between instability and the number of insects captured at high levels. It seems probable, therefore, that migratory flights of these birds could be correlated with days and areas of instability.

Nocturnal migrants, however, are influenced by other factors. They do not soar; therefore, they are not assisted by rising currents. They do not feed in the air; therefore unstable air is of no advantage to them. In fact, it is my belief that exactly the opposite condition, atmospheric stability, is most favorable for nocturnal migration. It has been generally assumed that most small land birds migrate by night in order to feed by day and although this may well be an important consideration, it will also be shown that flying conditions at night are more favorable for these migrants.

METEOROLOGICAL BACKGROUND

The degree of stability in the atmosphere is a function of the lapse rate, the amount of temperature change with height (Figure 1). If the lapse rate exceeds 1° C per 100 meters as it usually does in the lower layers during the day, the air is unstable. When this condition exists, air which is heated by contact with the earth's surface tends to rise and is replaced by the sinking of cooler air from aloft. Thus, vertical motion is set up in the atmosphere in addition to the horizontal motion represented by the wind direction and velocity. In an unstable atmosphere, the air flow is turbulent. Turbulence may be defined as departure from a mean motion. For example, the mean wind direction over a given period of time may be northwest or from 315° at 10 miles per hour. If the measuring instrument does not deviate from 315° and 10 miles per hour throughout the period, no turbulence on a scale measurable by the instrument exists. If, however, the wind fluctuates between west and north and between 5 and 15 miles per hour, as might commonly be the case, each deviation from northwest and from 10 miles per hour represents turbulent motion.

In a similar fashion an instrument may be set up to measure vertical motion. If this vane remains horizontal throughout a given period, no measurable vertical turbulence is present. If, however, the vane fluctuates up and down over a number of angular degrees in response to the passing up and down drafts, vertical turbulence is present. Studies at Brookhaven National Laboratory (Singer and Smith, 1953), where three bivanes as well as seven Bendix-Friez aerovanes are in continuous use on the 420-foot meteorology tower, show that both vertical and horizontal turbulence are always present whenever an unstable lapse rate exists. When the lapse rate is between 1° C per 100 meters and zero, the air may be either conditionally unstable (unstable only when lifted mechanically) or stable. Under these conditions, turbulence continues to exist but becomes progressively less as the lapse rate decreases.

When temperature increases with height, the condition is termed an inversion since the normal temperature structure is inverted. Inversions near the surface form almost entirely by night, when instead of receiving heat from the sun, the earth radiates heat back to space thereby cooling its surface. As the surface cools, the air near it is also cooled, and when it reaches a temperature lower than that of the air above, an inversion has formed. Inversions form on about two-thirds of all nights over suitable terrain. The two inhibiting

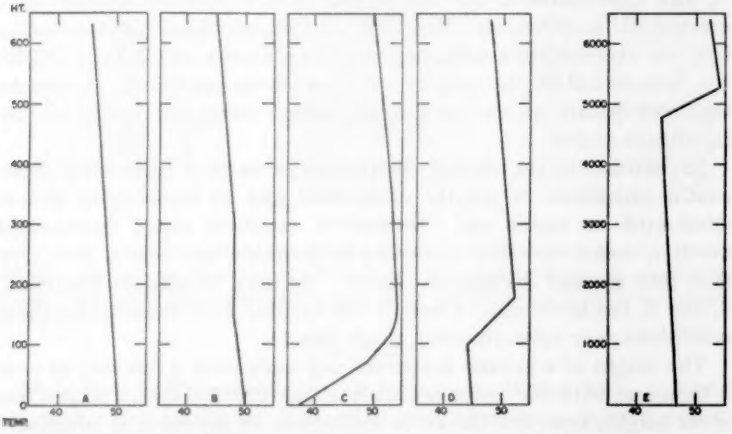

FIGURE 1. Five typical cases of temperature change with height: A, lapse; B, isothermal layer; C, ground inversion; D, low level inversion; E, high level or frontal inversion.

factors that are primarily responsible for preventing inversion formation are cloudiness and wind speed. Clouds reflect and re-radiate most of the outgoing radiation, and if enough are present, prevent the surface from cooling enough to form an inversion. By mixing the cooling lower air with warmer upper air, high wind velocities also prevent inversion formation. Thus, nights with rather low surface wind speed and with the major portion of the sky free of low or middle clouds are most favorable for inversion formation. Either increased wind speed or increased cloud cover may break up an inversion after it has formed, although a cloud layer forming about sunrise may prolong the inversion into the daylight hours. The usual cause of inversion breakup, however, is the appearance of the morning sun which heats the earth's surface. This in turn heats the lower air until its temperature exceeds that of the air aloft. At this point the inversion ceases to exist. Although inversion formation and breakup are usually quite rapid, an intermediate condition,

called isothermal, in which temperature remains the same with height, may exist for some time during the change from lapse to inversion or from inversion to lapse.

It has been found that under inversion conditions vertical motion on a significant scale virtually disappears. It is obvious that convective effects can not be operative since the colder, heavier air is now at the bottom and the warmer, lighter air is at the top. Mechanical turbulence also is quickly eliminated in this stable air so that at any appreciable height above the surface, vertical motion on a measurable scale ceases. This may be demonstrated by introducing into the atmosphere a substance such as a smoke which has particles too light to fall out by gravity. Under stable conditions, the smoke trail will remain at the same level, neither rising nor falling to any significant extent.

In addition to the virtual elimination of vertical turbulence, horizontal turbulence is greatly diminished and in some cases almost eliminated in stable air. Instead of constant rapid fluctuations about a mean direction as occurs in unstable air, only a few very slow and gradual fluctuations occur. As may be seen in Figures 2, 3, and 4, the horizontal as well as the vertical wind trace under these conditions may approximate a single line.

The height of a ground inversion may vary from a few feet to over a thousand with the mean probably about 400–500 feet. Regardless of its height, however, the air in and above an inversion is effectively isolated from turbulence originating from below. Thus, the stratified wind flow is present not only within but also above the inversion structure.

In addition to these low level ground inversions, higher level inversions are fairly common. They are usually caused by warmer air flowing over colder air at a frontal surface, the discontinuity line between two air masses. Frontal inversions are most common and best developed at a warm front surface aloft. At a warm front with a shallow slope the inversion may extend for several hundred miles north and south without being more than a mile above the earth's surface at its northern end, and it may extend for hundreds of miles east and west along a well developed warm front. In contrast to ground inversions, frontal inversions persist independently of wind speed, cloudiness, or time of day.

For the purpose of this study, air is classed as stable only if an isothermal layer or an inversion actually exists. All other cases are classed as unstable although from a strict meteorological standpoint, some of them are stable also. It must be emphasized, however, that

areas of stability have no consistent relationship with pressure, temperature, or wind direction. Ground inversions may occur in any situation where sufficient cooling of the earth takes place at night and frontal inversions occur whenever warmer air is lifted by cooler air.

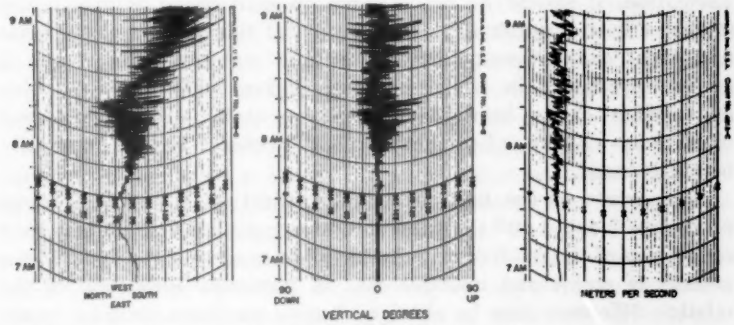

FIGURE 2 (*left*) Horizontal, and Figure 3 (*center*) vertical wind direction traces showing the increase in turbulence from stable to unstable conditions. FIGURE 4 (*right*) Wind speed trace showing the increase in variability under the same change in conditions.

HYPOTHESIS

McMillan (1938) advanced the hypothesis that a bird in flight becomes a part of the air flow and is unaffected by turbulence except when landing or taking off. This would be true if the bird were a weightless body suspended in the air through no effort of its own and content to drift wherever the wind carried it. However, a bird actually remains aloft only by the expenditure of a certain amount of energy, and a bird in flight is normally trying to follow a more or less specific route and reach a definite objective, be it the nearest tree or a breeding area hundreds of miles away. Therefore, the bird in attempting to follow a course and maintain an altitude is necessarily subject to any forces acting upon him. High speed photography has shown us that a bird's flight surfaces are capable of great adjustment in meeting the various forces encountered in flight. It is obvious, however, that such adjustments, each necessitating muscular action, involve the expenditure of a small amount of energy. It is also apparent that a bird flying through unstable air and meeting constant fluctuations in both the horizontal and vertical wind directions as well as frequent variations in wind speed is forced to readjust his flight surfaces continually in order to maintain a constant height and direction. On the other hand, flight through

stable air with no significant vertical fluctuations, with only a few gradual horizontal fluctuations, and with little variation in wind speed, would necessitate adjustment to only one relatively constant force. Therefore, such flight should be more economical of energy. Futhermore if, as has been postulated, birds make use of air flow in navigation, it should be much easier to maintain a course in the stratified flow of stable air. It is my belief that nocturnal migrants find flight easier through stable air, that stable conditions are of major importance in triggering such flights, and that a positive relationship exists between atmospheric stability and nocturnal migrations. As far as I can determine, this concept has not previously been advanced.

Comparison of the horizontal and vertical wind direction traces in Figures 2 and 3 and the wind speed trace in Figure 4, gives a good conception of the relative magnitude and frequency of the fluctuations present in stable and unstable air. A numerical indication of the relative difference may be obtained from a gustiness totalizer in use at the Brookhaven National Laboratory Meteorology Group. This device measures all horizontal gusts strong enough to move a Bendix-Friez aerovane in units of angular degrees of rotation of the vane. Thus, each deviation from a mean direction is measured and totalized. Under normal unstable conditions a mean of over 10,000 degrees of rotation per hour or about 1700 per minute has been found. On the other hand, under stable conditions a mean of about 400 degrees of rotation per hour or about 7 per minute has been found. Therefore, we find about two hundred and fifty times as much horizontal variability present in unstable air as is present in stable air. Although such measurements have not yet been made on vertical variability, other studies lead to the belief that a similar proportion and order of magnitude exist there. Although it is impossible to determine how much of this turbulent force is of such a scale as to affect the flight of a small bird, a fair assumption would be that a considerable portion of it is.

As an observational basis for the hypothesis outlined above, observations show that most nocturnal migrations take place under stable conditions. Flights do not usually begin until after the time that inversions normally form in the evening and usually terminate before or at the time of inversion breakup in the morning.

METEOROLOGICAL DATA

In order to test the hypothesis described above, an extensive analysis of the 1953 spring migration and its relationship to a number

of meteorological variables was undertaken. Three separate maps of selected meteorological conditions were prepared for each night from April 1–2 to May 30–31, 1953. The first set of maps, Figure 5, prepared from data taken from the 10 P.M. EST radiosondes, delineates stable and unstable areas. About 53 stations in the area regularly take radiosondes, but on any given night a number of reports is usually missing. The mean number of reports from which each night's map was prepared was 44. From an inspection of the coded data as obtained from the teletype reports, it was possible to determine whether or not an inversion existed at each station.

If an inversion or an isothermal layer existed below 3,000 feet, the area was classified as stable. If no inversion existed in the lower layers the area was classified unstable. The three types of areas were distinguished on the maps by different colors. Normally, the stable and unstable stations grouped themselves into homogeneous areas and little problem existed in determining the approximate boundary lines. In a few doubtful cases, reference to surface conditions was often helpful. In a few cases of missing data, certain areas could not be classified. Migration reports from these areas were not used.

It was found that an average of 67 per cent of the area was stable each night and 33 per cent unstable, but considerable change took place from night to night both in the percentage and areas in each category. It is realized that a measurement taken once a night at each station is not necessarily indicative of conditions existing throughout the night. It is probable that in some areas an inversion formed after the sounding was taken and that in other cases the inversion was destroyed later in the night. However, no other measure of stability is available and the data are undoubtedly representative of conditions throughout the night at the stations and in surrounding areas on most occasions. Studies at Brookhaven National Laboratory where continuous temperature measurements are made at various levels up to 410 feet show that most inversions have formed by 10 P.M. EST and generally persist for most of the night.

A second set of maps was prepared showing wind direction and velocity at 2000 feet over the same region. In the light of measurements on the height of nocturnal migrants given by Chapman (1888), Winkenwerder (1902), Carpenter (1906), Stebbins (1906), and Wetmore (1926), it was felt that this level is as close to the mean flight level as can be obtained. These wind data were obtained from pilot balloon observations taken at the same hour as the radiosondes. Approximately 107 stations in the area regularly take pilot balloon measurements, but because of unfavorable conditions, runs are not

always successful. An average of 79 stations per night was obtained and plotted, giving an adequate sample in all cases. Pibal reports are available every six hours, but since important changes in upper air flow are seldom rapid, the one report may be considered representative of the night.

The third set of maps was prepared from surface data taken from the 1:30 A.M. EST Weather Bureau maps as a test of the possibility of judging favorable migration nights from surface conditions. Areas were classified as favorable, intermediate, or unfavorable for migration. The first category included areas with mostly clear skies and light surface winds. Unfavorable areas were those with precipitation, heavy fog, or strong winds and frontal zones. Intermediate areas were all other.

In addition, the 1:30 A.M. EST Weather Bureau maps were used directly in correlating movements with surface conditions. All maps were prepared as the data became available and before any migration data were received. Thus, no bias was introduced into the maps by a prior knowledge of bird movements.

MIGRATION DATA

Migration data were obtained from many sources. When the project was initiated, a form letter was sent to several hundred observers in the area covered, requesting definite dates of arrival or departure or actual observations of nocturnal migrants overhead. Although the response was not as good as anticipated, a considerable amount of reliable data was obtained in this manner. Other reports were obtained from Audubon Field Notes, from various local publications, and from the files of the U. S. Fish and Wildlife Service. In addition, the data from the co-operative migration study initiated by Mr. James H. Zimmerman, were made available and furnished the largest class of data obtained. About 2500 usable reports were received, some from all portions of the area but relatively few from areas with few observers. Because of the varying reliability of the data, it was judged best to divide it into two classes. Class 1 data included all reports in which no doubt existed as to the actual night of movement while in Class 2 reports, the possibility exists that some arrivals or departures were not actually on the night specified. Although this classification is arbitrary and many of the Class 2 reports probably deserve to be in Class 1, the value of the separation is shown by the fact that Class 1 reports show a better correlation with the expected meteorological variables than the Class 2 reports.

As the data were received, they were placed on each of the maps

using appropriate symbols for each type of movement and for each class of data. Major waves were separated from other arrivals by the number of species and individuals involved. Figure 5, a map of the area on the night of April 27–28, illustrates the method of plotting migration reports. It will be noted that all the major waves and the bulk of the arrivals occurred in stable areas. Although some arrivals

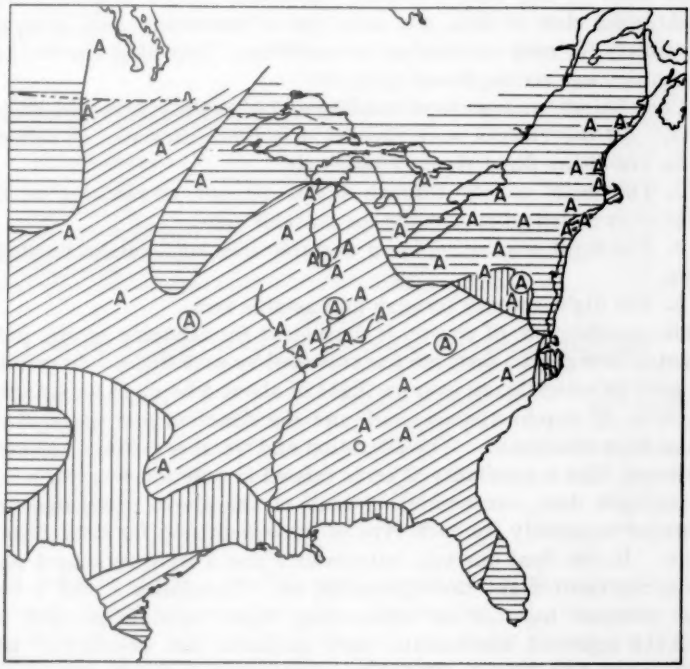

FIGURE 5. Map illustrating method of mapping stable and unstable areas and of plotting migration reports. Slanted hatching, stable area; horizontal hatching, unstable area; vertical hatching, isothermal area; A, arrival; A circled, wave arrival; D, departure; O, overhead observation.

were recorded in the unstable area in the northeast, the number is small considering the large number of observers there and the numerous reports received from that area under stable conditions. All reports received were plotted separately except where different observers reported the same movement from the same or closely adjacent localities. In this case, the reports were plotted as one. No distinction was made between species since it was assumed that

all nocturnal land bird migrants react to similar conditions. Separating the data into classes for each species would have hopelessly complicated the study.

METHOD AND RESULTS

When all data received had been plotted, correlations were made with each of the meteorological variables. In all analyses, each night, each class of data, and each type of movement were analyzed separately for each meteorological condition. Grouping into broader categories was accomplished later.

Correlations with areas of stability and instability were undertaken first. All movements were divided into four categories as follows:

1. The entire flight through stable air.
2. The flight mainly through stable air but terminating at the edge of or a short distance into an unstable area.
3. The flight originating in an unstable area but ending in a stable area.
4. The flight entirely through an unstable area.

This classification, of course, is dependent for accuracy on my judgment of how great a distance was travelled by each flight. In arriving at such an estimate, an average flight of about 8 hours at an air speed of 20 to 25 m.p.h. was assumed, and the direction and speed of the wind were considered. The migration and weather pattern was such, however, that a possibility of error existed in only a few cases.

On each date, occurrences in each of the above categories were counted separately for each type of movement and for each class of data. In the final analysis, categories 1 and 2 were combined since both represent flight through stable air. Categories 3 and 4 were also grouped together as representing flight through unstable air.

2,414 reported movements were available for correlation with atmospheric stability. These cases were divided into 155 major waves, 2,075 arrivals, 175 departures, and 9 overhead observations. They were also divided into 363 Class 1 movements and 2,051 Class 2 movements. These cases are summarized in Tables 1 to 3 where the number and percentage of occurrence in stable air of each type of movement are given. It will be noted that the Class 1 data show that about 88 per cent of all movements occur in stable air compared to 74 per cent of Class 2 movements. The arrival of major waves reported in the two classes of data compares more favorably, 88 and 85 per cent. It is apparent that a report of the arrival of a large flight is much less subject to error than a report of the arrival of one or a few individuals.

TABLE 1

PERCENTAGE OF CLASS 1 MIGRATORY MOVEMENTS OCCURRING IN STABLE AIR

Type of movement	*Number of cases*	*Percentage in stable air*
All movements	363	88.4
Major waves	69	88.4
All other movements	294	88.4
Arrivals	234	89.3
Departures	51	84.3
Overhead	9	88.9

TABLE 2

PERCENTAGE OF CLASS 2 MIGRATORY MOVEMENTS OCCURRING IN STABLE AIR

Type of movement	*Number of cases*	*Percentage in stable air*
All movements	2051	74.0
Major waves	86	84.7
All other movements	1966	73.4
Arrivals	1842	73.5
Departures	124	73.4

TABLE 3

PERCENTAGE OF ALL MIGRATORY MOVEMENTS OCCURRING IN STABLE AIR

Type of movement	*Number of cases*	*Percentage in stable air*
All movements	2414	76.1
Major waves	155	86.4
All other movements	2259	75.4
Arrivals	2075	75.3
Departures	175	76.6
Overhead	9	88.9

In order to obtain a mathematical evaluation of these results, the following procedure was followed. An analysis of the radiosonde data showed that 67 per cent of the area was stable during the period studied and 33 per cent unstable. Therefore, if birds flew at random without regard to stability or the factors associated with it, 67 per cent of the flights would be expected through stable areas and 33 per cent through unstable areas. However, 76 per cent of all movements, 86 per cent of all major waves, and 88 per cent of all Class 1 movements occurred under stable conditions. To test the significance of this, the assumption was made that the flights were randomly distributed with respect to stability and the method given by Kenney (1944) was followed.

The evaluation was obtained by use of the formulas:

$\bar{X} = SP$ and $\sigma^2 = SPG$ where $\bar{X}$ = the mean number of flights expected through stable air, S = the total number of cases, P = the

probability of flight through stable air, G = the probability of flight through unstable air, and σ = the standard deviation.

Substituting data from the total of all movements, $\overline{X} = 2414 \times 0.67$ or 1617 and $\sigma^2 = 1617 \times 0.33$ or 533.6. Therefore $\sigma = 23$. Subtracting $\overline{X}$ from the number of cases observed of flight through stable air, we obtain 1838−1617 or 221 which is 9.6 σ. The odds against obtaining this result by chance are greater than 99.99 to 1, so we may conclude that the results are highly significant.

Repeating the procedure with the major waves from both classes of data, we find a probability of 104 cases and an occurrence of 134 cases. The deviation of 30 is 5.2 σ and again highly significant.

A similar procedure was followed with the 2,000-foot wind data. Winds were classed as favorable if they were more with than against the assumed direction of flight and unfavorable if they were more against. The flight direction was assumed to be normal in the area involved, northerly in the mid-west, north to northeast in the northeastern states and north to northwest in the plains states. The few borderline cases were classed as side winds. 4737 wind observations were available, 2306 favorable, 1739 unfavorable, 671 side, and 19 calm. Using only the 4045 distinct cases we find 57 per cent favorable and 43 per cent unfavorable. Therefore, if the birds flew at random in respect to wind direction we would expect 57 per cent of the flights with favorable winds and 43 per cent with unfavorable winds, omitting the side wind flights. Tables 4 to 6 give the actual number of cases observed. It will be noted that 67 per cent of all Class 1 cases, 79 per cent of all major waves, and 63 per cent of all movements occurred with favorable winds.

Considering all cases we find a probability of 1284, an occurrence of 1416 and a deviation of 132 or 5.6σ. Using only the major waves, we obtain a deviation of 29 or 4.8 σ. These results are again highly significant.

Since it is evident that both atmospheric stability and wind

TABLE 4

PERCENTAGE OF CLASS 1 MIGRATORY MOVEMENTS OCCURRING WITH FAVORABLE WINDS ALOFT

Type of movement	*Number of cases*	*Percentage with favorable winds*
All movements	340	67.1
Major waves	66	77.3
Other movements	274	64.6
Arrivals	218	66.1
Departures	47	57.4
Overhead	9	66.7

TABLE 5

PERCENTAGE OF CLASS 2 MIGRATORY MOVEMENTS OCCURRING WITH FAVORABLE WINDS ALOFT

Type of movement	*Number of cases*	*Percentage with favorable winds*
All movements	1931	62.1
Major waves	79	79.7
Other movements	1834	61.3
Arrivals	1717	61.2
Departures	117	62.4

TABLE 6

PERCENTAGE OF ALL MIGRATORY MOVEMENTS OCCURRING WITH FAVORABLE WINDS ALOFT

Type of movement	*Number of cases*	*Percentage with favorable winds*
All movements	2253	62.8
Major waves	145	78.6
Other movements	2108	61.7
Arrivals	1935	61.2
Departures	164	61.0
Overhead	9	66.7

direction are of importance in nocturnal bird migration, it was desired to evaluate their combined importance and to test the influence of each separately. For these purposes only the major waves were used since they were judged more reliable than the bulk of the data. The 153 usable waves were divided into four categories as follows:

1. Flight through stable air with favorable winds.
2. Flight through stable air with unfavorable winds.
3. Flight through unstable air with favorable winds.
4. Flight through unstable air with unfavorable winds.

The number of cases, the percentage in each category and the percentage of probability are given in Table 7. In the first category, we find 98 cases with a probability of 58. The deviation, 40, is 6.7 σ and is highly significant. In the second category, we find 24 per cent of the flights or 83 per cent of the probable number. In the third category, however, we find only 10 per cent of the flights or 53 per cent of those probable. The last category contains only 14 per cent of the number expected.

From the above figures it is evident that the overwhelming majority of all flights took place in areas of stable air and favorable winds, but the fact that the cases in Category 2 are much closer to the probability than the cases in Category 3 indicates that stability is probably of greater importance than wind direction. In the light of these

TABLE 7

PERCENTAGE OF MAJOR WAVES OCCURRING AND PROBABILITY OF OCCURRENCE UNDER VARIOUS COMBINATIONS OF STABILITY AND WIND DIRECTION

Category of movement	*Number of cases*	*Percentage*	*Percentage of probability*
With stable air and favorable wind	98	64	38
With stable air and unfavorable wind	36	24	29
With unstable air and favorable wind	15	10	19
With unstable air and unfavorable wind	4	2	14

findings, it was decided to examine in greater detail the 55 cases in the last 3 categories in the hope of finding why these flights did not conform to the normal pattern.

The 36 cases of flight through stable air but against the wind were examined first. No case was found with flight against wind speeds greater than 18 m.p.h. 18 cases were of flight over a warm front and therefore the flights almost certainly took place with favorable winds at a higher level even though they terminated in areas of unfavorable winds at 2,000 feet. Two cases were doubtful and might have taken place with favorable winds. Four cases had favorable winds a short distance to the south. These flights were evidentally terminated shortly after the unfavorable winds were encountered. The remaining 12 flights took place against light winds, mostly 5 to 10 m.p.h. and none greater than 18 m.p.h. It might be mentioned here that a number of cases taken from Class 2 data reported arrival in an area of strong unfavorable winds. In some cases flight may have been made at a different level with lighter winds, but it is believed that most of these observations are in error.

The 15 cases of flight with favorable winds but unstable air were examined next. Four cases were of flight over a warm front surface, most probably in a higher level inversion not plotted on the map. Five cases occurred in the warm sector of a low with strong southerly winds and a stable area to the south. It is probable that these flights originated in the stable area and were carried beyond by the high wind speed. Four other cases might have originated in a stable area some distance to the south while no explanation was found for only the two remaining cases.

The four cases occurring with unfavorable winds and unstable air were next examined. One case occurred over a warm front surface where favorable winds and stable air existed at a higher level. The other three cases were in regions where a stable area with favorable wind existed to the south. The flight was evidently maintained for some time into the unfavorable conditions.

In the light of these findings, it is evident that only a very few valid cases can be found of large flights through an unstable area or against an opposing wind and that the overwhelming majority of mass flights took place under favorable wind and stability conditions.

Surface conditions were considered next and again only major waves were used. At the beginning of the study, I felt that it might be possible to determine which areas were favorable for nocturnal migration from an inspection of the surface map. Accordingly, the third set of maps showing areas that were, in my judgment, favorable, intermediate, and unfavorable, was examined. Although a precise determination of probabilities is not possible, I estimated that about 50 per cent of the area fell into the intermediate category and about 25 per cent into each of the other two. However, only 28 per cent of the reported flights took place in the intermediate areas, 27 per cent in the favorable areas, and 45 per cent in the unfavorable areas. The latter class, of course, includes the warm front areas now found to be favorable for nocturnal migration. It is obvious, however, that the classification used is of little value and my estimate of favorable conditions as judged from surface data only is not shared by the birds.

The next step was to test for relationships between the major waves and the various surface variables. Pressure systems were considered first. It was found that 47 or 31 per cent of the flights took place through high pressure areas. Of these, 10 were through the eastern portion of a high where opposing winds normally prevailed, 25 through the central portion where winds were usually light and variable, and 12 through the western section where winds were favorable. Ground inversions are most common near the center of highs where skies are relatively clear and winds light.

28 flights or 18 per cent of the total took place in the immediate vicinity of a cold front. It was not always possible to determine if they arrived ahead of or behind the front since their time of arrival during the night was not known, but nearly all the flights could have and probably did arrive before or at the time of the frontal passage while favorable winds still prevailed. It is evident that spring migrants do not favor cold frontal areas. Indications are that flights encountering such areas are usually terminated.

78 or 51 per cent of the total took place in the vicinity of a warm front. 14 terminated in the vicinity of the front, 29 apparently flew over the surface front and came down in the cooler air not far to the north, while 35 terminated more than 100 miles to the north.

All of these flights, however, probably flew through the warm air and southerly winds aloft rather than through the less favorable conditions below. Thus, it is obvious that warm front inversions are of considerable importance in the northward movement.

58 or 37 per cent of the flights took place wholly or partly in a precipitation area. 29 flights ended near the edge of the area, 17 ended some distance into the area, 7 passed through or over the area, and 5 may have originated in a precipitation area. These flights are mostly the same ones discussed above as taking place in warm front areas. It may be assumed that in all cases the flight was over rather than through the precipitation until the time of descent.

A comparison with surface temperature trends was made next. Computations showed that 57 per cent of the area was in a region of rising temperatures and 43 per cent in a region of falling temperatures. 88 or 56 per cent of the flights took place in the former areas and 65 or 44 per cent in the latter showing that flights were apparently random in respect to temperature trends. Although previous studies have shown a relationship between rising temperatures and spring migration, rising temperatures are predominant in spring and they co-exist with favorable winds. Therefore, although the major portion of spring migration may take place with rising temperatures, this study fails to show a correlation greater than the probability.

A similar comparison was made with pressure trends. It was estimated that about 50 per cent of the area had rising pressures and 50 per cent falling pressures. 68 or 47 per cent of the flights took place in regions of rising pressure while 76 or 53 per cent occurred in areas of falling pressure. The deviation of 4 is 0.67 σ. Although a slight relationship appears to exist, pressure as such is judged to be of no importance. Areas of falling pressure are associated with other conditions that are important as discussed above.

The only surface variable that showed a correlation comparable to the upper air variables was wind direction. The percentages of favorable and unfavorable direction at the surface were identical with those at 2,000 feet, namely 57 and 43 per cent. 75 per cent of the flights were made with favorable surface wind and 25 per cent with an unfavorable direction. The deviation of 25 is 4.3 σ, only slightly less than that found at 2,000 feet.

Although the frequency percentages of northerly and southerly winds are identical over the area and the period as a whole at both levels, it does not necessarily mean that they always occur simultaneously. In the majority of cases they do, but at a warm front

surface in particular, surface winds may differ radically from those aloft over a wide area. If this situation is taken into account, it is possible that surface winds may be nearly as useful as winds aloft for correlation with migration data.

As mentioned above, the relationship of moonlight to nocturnal movements needs investigating. Two periods of full moon occurred during the time covered by this study and neither was accompanied by a significant increase in reported movements. Many additional data must be accumulated, however, before any conclusions can be drawn.

DISCUSSION

Although the conclusion can be drawn that stable air and favorable winds aloft are of the utmost importance in springtime nocturnal bird migration, it must be regarded as tentative until more than one season can be studied. However, the length of time used, the large area covered, the large number of observations considered, and the excellent relationships found, all tend to increase the probable reliability of the results.

If, for the sake of discussion, we regard the results as valid, certain questions arise. Although the relationship with wind direction is simple, the correlation apparently found with stability could be with stability itself or with conditions associated with stability. An examination of the conditions causing and associated with stability leads to the conclusion that the relationship must be with stability itself. The two types of inversions causing stable air are caused by and are associated with widely differing weather conditions. Yet, each has been found favorable for nocturnal migration. Since stable air is the only variable common to both regimes its importance can not be minimized.

It is also necessary to consider how birds recognize stability and what stimuli are actually operative in triggering a migratory movement. Although this problem is susceptible to experimental solution and should be so tested, we can consider at present only indirect evidence. It seems well established that birds' sensory systems are no less sensitive than are those of humans. If that is so, changes in temperature and wind structure that accompany an inversion can easily be detected by the bird. I have many times had the experience of standing on a tower or other elevated structure during an inversion and feeling the smooth, stratified wind flow which is readily distinguishable from the normal, turbulent flow present during lapse conditions. During a well developed inversion, the

temperature increase with height is also readily detectable upon an ascent of 50 feet or less. Therefore, if humans can sense the changes that accompany an inversion, it seems reasonable to believe that birds can also and may be stimulated to begin a flight by these changes.

This, of course, does not imply that a bird is capable of recognizing a frontal inversion from the ground even though it was found that many flights took place over such an inversion. It seems more probable that in such cases the migration started in the ground inversion to the south of the warm front and continued over the warm front inversion. The strong southerly flow usually existing in such situations would make possible flights of considerable length.

As far as I can ascertain, no ornithologist has ever witnessed the actual departure of migrants upon a nocturnal flight; their pre-departure behavior is therefore unknown. One account, however, given by Lowery (1945) may be interpretable as pre-departure activity and seems highly significant in view of the hypothesis advanced above. He quoted a letter from Weston who towards sunset on a clear, mild, spring day noted a group of migrants congregated in the tops of the tallest trees. The birds occasionally made short upward flights beyond the tree tops, returning each time to the trees. This activity continued until after dark, and in the morning the birds were gone. Similar activity was observed on another occasion. It will be noted that the weather conditions described were favorable for ground inversion formation. It seems probable that the birds were testing the wind or temperature structure by their short upward flights and that migration began when conditions became favorable.

Since we now have a reasonable theory to explain how and why nocturnal migratory flights are initiated, we must consider how and why they are terminated. It is apparent that termination may be either voluntary or involuntary. The former would include cases in which the bird arrived at his destination or remained aloft until a normal hour for descent, probably shortly before sunrise or somewhat later in certain species. Involuntary terminations would include those cases in which the bird found himself faced with unfavorable or impossible flying conditions. These probably include strong, adverse winds, precipitation at the flight level, and turbulent air. The relatively large number of cases in which arrivals occurred at the edge of a precipitation area, at a frontal zone or at the southern edge of an area of opposing wind or unstable air suggests that many flights may not be terminated voluntarily. Numerous instances in the literature of birds arriving in an area of widespread rain and of being "precipitated out" in an area of thunderstorms support this belief.

It seems probable that many flights above warm fronts may be so ended. As the bird flies northward in the warm air, he has the advantages of stable air and favorable winds. Below him, however, lies unstable air, and usually unfavorable winds or precipitation. In order to stay in the warm air, he must constantly increase his altitude since the front slopes upwards from south to north. Eventually an altitude may be reached at which the bird will no longer be willing or able to continue flight. In this case, he will be forced to descend even though most unfavorable conditions may exist below. It is probable that the various cases of mass destruction overtaking spring migrants were caused in this way.

Although the cases have not been investigated individually, it seems probable that many of the instances wherein spring migrants apparently overshoot their mark and arrive either exceptionally early or well north of their normal range can be explained in a similar fashion. A bird flying above a frontal surface with adverse conditions below might well prefer to prolong his flight rather than descend until descent became necessary. Winds of 40 to 50 miles per hour are not uncommon at a few thousand feet in such situations. Thus, a bird with a flight speed of only 20 miles per hour could easily cover 600 or 700 miles in a single night. Such a flight could take a migrant from the Carolinas to the New England area and from the Gulf Coast to central Illinois, Indiana, or Ohio in a single night.

Although the controversial subject of trans-Gulf migration is beyond the scope of this paper, it might be pointed out that colder air over warmer water is subject to considerable instability but that warmer air over cooler water is relatively stable. Therefore, if stability along the route is a factor in over-water flight, northward movements should be correlated with the presence of air warmer than the water. This condition exists with a southerly circulation so that over the Gulf, favorable temperature structure and favorable wind direction should co-exist.

On the other hand, it is possible that only conditions at the starting point govern the time of trans-Gulf flights. Data obtained by Lowery (1945) tend to show a correlation between good weather (favorable for inversions) and southerly winds in Yucatan and arrivals on the Gulf coast when such arrivals are arrested there by a cold front.

Although the data show that migratory movements are correlated with certain favorable meteorological factors, it must not be expected that flights will occur whenever such conditions exist. If birds in the area are not yet ready to migrate or if all birds that were ready have departed on a previous, favorable night, no migration will take

place. On the other hand, a limited amount of migration may take place even under unfavorable conditions if the bird's urge to migrate outweighs his reluctance to fly under such conditions. It seems probable that if favorable conditions are long delayed, considerable movement will take place anyway.

It should be pointed out that the relationships found cannot be extrapolated to another area, to another season, or to another type of migrant. Data available indicate that the fall movement is influenced by quite different synoptic situations although it is believed that stability and wind direction are again of importance. It is expected that weather-migration relationships may be quite different in mountainous regions such as the Rockies, and there is considerable doubt whether the same factors are operative in other continents where migration patterns differ quite widely from those in America. For this reason, references have been confined to work on this continent.

CONCLUSIONS

Of the various meteorological variables studied, only two, atmospheric stability and wind direction, give a good correlation with springtime nocturnal land bird migration. The two together give a better correlation than either separately, but stability seems somewhat more important than wind direction. Therefore, it is evident that such migration normally taken place with favorable winds in stable air which may be caused either by ground or frontal inversions. Such movements usually begin in areas of ground inversions but may continue above frontal inversions. Migration is probably initiated by changes in temperature or wind structure or both, and these act as stimuli to the migrant. Migratory flights are often terminated at the edge of an unstable area or a region of unfavorable winds. A number of previously puzzling migration problems may be explainable on the basis of these findings.

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THE MONOTONY-THRESHOLD IN SINGING BIRDS

BY CHARLES HARTSHORNE

WHAT stimulates animal organisms is change; what deadens response is sameness, or persistent repetition. This is true especially of repetition at brief intervals; for with long intervals, the "attention span" is exceeded, there is fading of "memory" in the immediate or active sense. (Latent memory, conditioning with associative recall, is another matter; even in a bird it may span long periods; but we are speaking of what needs no recall, since it has yet to be forgotten.) With long intervals, brain cells perhaps revert approximately to their previous state, other activities intervene, and thus the tenth or hundredth occurrence of the repetitive factor is experienced in its contrast with these intervening events, or with a certain "freshness," and not as monotonously repetitive. If then there could be "intolerable monotony" for an animal, it would be produced by many repetitions unrelieved by substantial pauses. Applying this to bird song, we deduce that a bird which sings the same song over and over will probably have marked pauses between reiterations of the song, while birds without the tendency to such pauses will have at least several different songs and will avoid using any one of them over and over in direct succession. In other words, repetitious or "non-versatile" songsters must be "discontinuous," and continuous songsters must be versatile. Let us now define these terms more closely.

First, as to *versatility:* an individual may sing an identical song—neglecting seasonal changes and very slight or infrequent deviations—hundreds or thousands of times per day (or night); or, on the contrary, it may have a repertoire of several or many different songs or phrases sung in no fixed order, many or all of which are used in every performance lasting beyond a minute or two. Species each normal individual of which has a repertoire of four or more distinct songs or phrases (employed as just explained) we shall term "versatile." The majority of the world's most famous songsters are examples. Species essentially repetitious we shall term "non-versatile," especially if the song is brief and simple, relatively lacking in internal variety of pitch, rhythm, and so on, for example, the Prothonotary Warbler (*Protonotaria citrea*). Species intermediate in variety we term "semi-versatile," as for example, some of the wrens to be considered below.

Another way of singing we shall call the "eventually versatile" way. There is a repertoire of songs, but an individual sings each song a good many times before introducing another. In the short

run, then, such a singer does not differ much, if at all, from a non-versatile singer. Thus the Eastern Meadowlark (*Sturnella magna*) often repeats one song, at intervals, over and over; yet Saunders (1935, 1951) has noted 53 *different* songs from one individual within an hour and believes that the normal repertoire is 100! Probably most "non-versatile" species are, in mild degree, eventually versatile (two or three songs, taking a whole day and a whole season into account). For most of the purposes of this paper, eventual versatility is a species of non-versatility.

Continuity concerns the extent to which singing is free from interruption, during a normal "performance period" of a minute or more, by "substantial pauses," silences longer than those separating notes within songs or phrases. There is no wholly sharp line between such pauses and musical "rests," such as those separating the phrases in songs of some thrushes of the genus *Hylocichla*, which are integral to the musical pattern; but if a bird habitually sings several or many notes a second for two or three seconds, and then is silent for eight or more seconds, this is highly discontinuous singing. With such a singer there is *much more silence than song*, during any period longer than a few seconds. A Grasshopper Sparrow (*Ammodramus savannarum*) may seem to be singing "steadily" for several minutes; but the four to six brief songs per minute, possibly one or two more in the early morning, occupy only from 8 to 12 seconds, leaving about 50 of silence. Thus the bird sings less than 20 per cent of the performance time; during the remaining 80 per cent, it may be watching the surroundings, listening to other birds, and the like. Now contrast this with the Brown Thrasher (*Toxostoma rufum*) which for minutes at a time pours out an almost solid stream of sounds. Such birds, during a normal performance, sing more than 50 per cent of the time. (During an entire day they may sing no more than some discontinuous singers; they tend to have longer gaps between performances.) These are the "continuous" songsters. Between the extremes are the "semi-continuous" ones, singing from 30 to 50 per cent of the performance period. (Reasons for choosing these ratios will appear presently.)

Something like a thousand species in the world are non-versatile, singing one song over and over dozens or hundreds of times in succession, and probably upwards of three hundred species are continuous; yet these two large classes (with scores of each of which I am familiar) seem scarcely to overlap in a single instance—among the true songbirds at least. Where is the Oscinine singer as repetitious as the Field or Vesper sparrows (*Spizella pusilla* and *Pooecetes gramineus*) or the

European Willow Warbler (*Phylloscopus trochilus*) and at the same time as continuous as the Brown Thrasher or the European Song Thrush (*Turdus ericetorum*)? Yet it ought, it seems, to be easier to repeat the same song over and over rapidly than to sing many different songs or phrases at an equal rate. Easier, except for the threat of monotony, at least to the listening bird, and to the singer if he is attending to what he is doing. Birds "adapt" quickly to continued stimulation of the same kind, that is, they turn their attention elsewhere. Only in two ways, it seems, can this "monotony-threshold" be avoided, either by varying the activity in question, here the singing, or by pausing long enough so that lapse of memory, and/or other activities, intervene.

It is to be borne in mind that singing is normally a deliberate or free performance. A bird can be driven by fear or a sense of urgency to fly faster or farther than it would otherwise fly, even to the point of great fatigue, as over a body of water. But singing is not urgent in the same immediate sense. Also, whereas flying serves primarily to transport the creature through space, the biological values of song are social and psychological, and thus the interestingness of the song, for performer and avian listener, is of its essence. Repetition carried so far as to inhibit attention and cause the activity to lapse into an automatism for the singer and a negligible stimulus for the listener (mate or rival) is scarcely compatible with the status of song in the bird's life.

If interest is maintained by pauses, rather than by versatility, how long must the pauses be? Our reasoning—which may be least correct with respect to very long or very short songs or phrases—is as follows. Most of the set songs or phrases are between one and three seconds in duration; few are more than five. The explanation seems to be that the span of attention, or of vivid memory, is about this length in most songbirds (Craig, 1943: 166). There is then a presumption that a longer song than usual means a longer memory span, and hence the need for longer pauses if each rendition is to be equivalent to a fresh start. Continuity, accordingly, is properly taken as a ratio. But what ratio will define "discontinuity," that is, pauses suitable for repetitious singing? It is clearly not enough that the pauses be slightly longer than the song, for this would mean that memory is only a little less than "vivid"; whereas a bird singing a unit a thousand times or more a day, as most of them do, must recover freshness virtually completely, must have almost *no* sense of what (from our point of view) it has just previously done. The pauses, then, must be *much* longer than the songs. Physiology or psychology

will eventually tell us a good deal, no doubt, about the sort of proportion we should expect here; but is it not reasonable that somewhat over twice the duration that can be grasped as a whole, as songs must be to be recognized, should be required for recovery of freshness? This is provided for by our definition of discontinuous singing as less than 30 per cent of the performance time, leaving at least 70 per cent of silence, or two and one-third times as much. This ratio was arrived at empirically, as an effort to make sense out of such facts as this, that many hundreds of repeated songs are between one and one-half and three seconds, while the shortest pauses for these range, with rare exceptions, between three and one-half and seven seconds, respectively, which our 70-30 ratio calls for. Or again this fact: as Craig (1943: 24, 25, 54, 62, 67, 72) showed, the Wood Pewee tends to sing his third, or special twilight, phrase an ever higher proportion of times as he changes from leisurely daylight singing to the many times faster rate of his "twilight" song; but this tendency is halted almost exactly at the proportion of 50 per cent for the preferred phrase. Why? Because, beyond this proportion, the phrase must sometimes be repeated immediately without intervention of either of the others, and the bird avoids immediate repetition of any phrase, above all this one, when its pauses are short, though it has no hesitation about repeating either of its daytime phrases many times over when singing with the long pauses (8 seconds or more, instead of 1) of its leisurely singing. We shall meet with other species that thus exhibit, through a dual mode of behavior, the difference between long pauses that make variety unnecessary and short ones that require it.

Consider the contrast between two species, the Ovenbird (*Seiurus aurocapillus*) and the Brown Thrasher. The Ovenbird has a song with little internal variety in each utterance, and the only variation from one utterance to the next is in the number of times the "teacher" occurs. If this three-second song were to be sung every five seconds or so, we human listeners, at least, would find the monotony very trying. But the bird seldom pauses less than 10 seconds, usually more than 20 (Hann, 1937; Nice, 1931). Now observe the Thrasher. He hastens on from phrase to phrase, immediately repeating most of them once or twice only, until, after a minute or two his repertoire has perhaps been exhausted and new items no longer appear, although the old ones may present themselves in new orders. Pauses are so short one can seldom time them definitely. A bird performing in this fashion is doing almost nothing but sing. It is his life, for the time being; he therefore puts into it whatever sense of complexity

he possesses. The sharp separation of song perch from feeding area on the ground is symptomatic of his concentration. The Ovenbird, on his lower perch, seems to be taking his much simpler song in his stride, so to speak, while largely intent on other things. His occasional flight song, with its extra variety, shows that his capacity to act in complex ways (which may not equal the Thrasher's) is not normally expressed to the full in his singing. The tendency toward very short pauses in the "singing" of various insects suggests that in their case the simple repetitive patterns (katy-dids, however, are somewhat versatile) may come closer to being a measure of the creature's capacity. Many of the lower orders of birds may be a little nearer to this level than the songbirds are.

The monotony-threshold, or limit of tolerance for repetition, thus doubtless varies from species to species. We may also reasonably suppose that a creature which is satisfied by small or poorly defined contrasts *within* its basic song-pattern will feel less need of variation in successive utterances of the pattern. Purer musical tones define more definite contrasts; a creature which nicely contrasts two or more relatively pure frequencies each time it sings will be more likely to feel the need for contrast between one utterance and the next, or for substantial pauses. We shall see that the striking cases of disproportionately low versatility relative to the continuity are furnished by species whose lack of sensitivity to the value of contrast is shown by the song they repeat as well as by the mode of repetition.

Three families of North American birds are outstanding in continuity of singing: the mockingbird-thrasher family or Mimidae, the thrushes or Turdidae, and the vireos or Vireonidae. Scarcely a member of these is less than semi-continuous. It is equally difficult to find one that is less than semi-versatile. For the Eastern United States it almost suffices to refer to the diagrams of the songs of representatives of these families given by Saunders (1935, 1951) in his unique *Guide to Bird Songs*. (Where not otherwise stated, each horizontal half inch in Saunders' diagrams stands for a second of time.) In a few cases we need to supplement his information. For the Veery (*Hylocichla fuscescens*) neither versatility nor continuity can be determined from the diagrams. We are told that "ordinarily" a bird sings the same song over and over, though sometimes it alternates two songs. In Cheboygan County, Michigan, I found that Veeries usually sang at least two distinct songs and avoided repeating the same song more than a few times without introducing a contrasting song. The songs were shorter than those described by Saunders—2, 3, 4, occasionally 5, downward slurs, instead of 5 or 6. (These

very probably constitute regional differences, as does the fact that the songs of most Vesper Sparrows in Cheboygan County *descend* in pitch after the opening note or two, instead of rising, as all the books say.) Songs were commonly at rates of 7 to 12 per minute, lasting about 1.5 seconds. This is scarcely continuous singing, and the versatility is similarly middling. (I once thought I heard an individual at sunset sing 10 times in 30 seconds, singing several sharply contrasting songs. If I was misled by two birds singing close together, the continuity and versatility were alike illusory.) Hermit Thrushes (*Hylocichla guttata*) have the most variety of the genus, considering the intricacy of the phrases; and while the pauses are mostly of about the same length as the phrases, approximately 2.3 seconds, the continuity is really almost 100 per cent, for the phrases are variations on a theme, with striking and never-failing contrasts of key, proving that the relation between a phrase and its successor is essential. Thus there is not so much a succession of brief songs as one complex song lasting half a minute or more, and then another such prolonged song after a pause more pronounced than those within the songs. Similar remarks, with suitable qualifications, apply to other members of the genus. The Robin (*Turdus migratorius*) has less effective variety in proportion to his continuity than other thrushes, and this is in keeping with the lack of musical sensitivity shown in the phrases themselves. The Bluebird (*Sialia sialis*) is somewhat (but not greatly—see Saunders, 1935) inferior to the Robin in versatility and not quite so continuous.

Going outside the region covered by Saunders, we have the Varied Thrush (*Ixoreus naevius*), which sings a prolonged, sometimes quavering note on five or six different pitches in no fixed order (Bent, 1949: 91). Continuity and versatility seem fairly high in this most unusual song. Intervals between sounds are said to be a second, and as I recall the notes they last about this time. This would make 120 notes in 4 minutes. Ninety-five were heard (Bent, 1949: 91–92) in less than this time, but the notes were given in series with longer pauses marking the end of a series, and since the same pitch was seldom used twice in succession, the intervals within a series may perhaps be considered integral to the music. Counting a harsh note now and then, the quavers or trills, and the ever-varying order of pitches, the variety seems no less impressive than the continuity. Townsend's Solitaire (*Myadestes townsendi*) sings without pause, usually for about 20 seconds (Hoffman, 1927: 252), very long for a single burst of sounds; there is, as I recall it, marked internal variety. The variety from one utterance to another would be difficult to as-

certain without instrumental analysis; nor has anyone reported what the usual intervals are.

Saunders attributes "considerable" variety to some individuals of the Warbling Vireo (*Vireo gilvus*). I timed a bird in Cheboygan County which gave 6.2 songs per minute; the length was about that reported by Saunders (3.2 seconds) giving a continuity of 33 per cent. There was some versatility: variations in length, and in beginnings and endings of songs. Bell's Vireo (*V. bellii*) is at times rather continuous, giving its song of 1.5 to 2.5 seconds (Saunders, 1951) 9 to 17 times a minute (Mumford, 1952: 230). This frequency, however, is poorly sustained; hourly records being low (Nice, 1928: 13). Moreover, versatility is considerable, the song having two basic forms, each with now a rising, now a falling, inflection ("like question and answer"). All four versions seem to be used even in a rather short sequence though there is also a fair amount of immediate repetition (Nice, 1929: 13). If there is here a slight disproportion between continuity and versatility, it is in accord with the lack (noted by all observers) of clear musical contrasts in the basic theme.

The same can be said more emphatically of what is probably the most repetitious member of the family, and one of the most repetitious oscinine birds anywhere, Hutton's Vireo (*V. huttoni*) which reiterates its kitten-like "me-ow" (said of the subspecies *stephensi*) or its "qui-id" about once a second for minutes at a time (Willard, 1908: 232; Bent, 1950: 246–47). Yet, even here, Bent quotes an observer who noted a "change of key" every minute or two, a phenomenon rare among birds. Also, for all one can tell from the accounts, the actual singing of the phrase, evidently as unmusical as any vireo's, occupies no more than one-third of a second. The most continuous vireo is presumably the Red-eyed (*V. olivaceus*), which often sings considerably faster than a phrase a second, though also often but 30 per minute. Saunders puts the number of different phrases for each bird at 20 to 30! The Black-capped Vireo (*V. atricapillus*) sings 30 times per minute and has "extraordinary variety" (Nice and Nice, 1931). The White-eyed Vireo (*V. griseus*) has "eventual variety" only, and (combining data from Nice and Nice, 1931, and Saunders, 1935) its continuity is 27 to 35 per cent—normal for this type of singing. Yellow-throated and Blue-headed vireos (*V. flavifrons* and *V. solitarius*) have far fewer phrases than the Red-eyed, though perhaps with more effective contrasts, and are less extreme in their continuity.

Nearly all the mockingbirds and thrashers have both high continuity and high versatility. (See Bent, 1948, and Saunders, 1951.)

A bird with a recognized tendency toward continuous singing is the Ruby-crowned Kinglet (*Regulus calendula*). I have watched this species in the Upper Peninsula of Michigan singing with fervor, its crest gleaming, with little pause for minutes. But the singing exhibited more versatility than one might guess from the literature. The ending of the song I particularly listened to was a "rub-a-chee" repeated, now four, now three, now two, now one and a half times. (A good many species practice this numerical juggling, as we shall see.) There were, I think, other modes of variation; at any rate the impression was not one of monotony. Nor has the bird impressed others as monotonous.

The Short-billed Marsh Wren (*Cistothorus platensis*) is said to sing as many as 12 songs per minute (Bent, 1948: 272), which with 2 seconds per song gives a continuity ratio of 40 per cent. I have heard one sing 15 times per minute in Cheboygan County; but this individual, which was in plain sight, sang at least 6 versions of his brief song, changing every few times. He juggled the numbers of notes in the latter part of the song, 2, 3, 4, 5 or more, he doubled the tempo of this part, or cut it in half again. This is medium-high versatility, almost equal to the continuity of 50 per cent. Again we have a slight lag in a bird whose basic theme is somewhat unmusical. The same remark applies to the Long-billed Marsh Wren (*Telmatodytes palustris*) which sometimes *averages* 25 songs per minute "when contesting for sites or when females arrive" (Welter, 1935: 11). According to Saunders (Bent, 1948: 258) songs last 1.2 to 2 seconds; supposing the average is 1.6, this gives a continuity of 66 per cent! Saunders also says that individuals vary their songs "considerably," and speaks of "five different songs from one individual." I have listened to one of these birds singing rather discontinuously and using two versions of his song; but I have also heard one with a higher rate (15 per minute) which kept making perceptible changes in pitch, tempo, and number of notes; and a day later, at the exact spot, presumably the same bird sang 16 to 20 times per minute with definitely still greater contrasts between successive songs. The House Wren (*Troglodytes aëdon*) notoriously impresses people as monotonous. However, playing a recording at slow speed, one finds a song so complex (and not ill-constructed) that the impression of obviousness disappears. There are reasons (for some of which see Ansley, 1954: 39) for supposing that this is closer to the way the bird hears its song. According to Saunders (Bent, 1948: 132) the songs last from 1.4 to 2.6 seconds, and this agrees roughly with my own few timings and those of Kendeigh (1941: 22). Let us say 2.3 on the average.

Kendeigh finds 11 or 12 songs per minute to be near the maximal rate; I have heard 9 to 11. Thus the maximal continuity is about 45 per cent, not comparable, for example, to the Long-billed Marsh Wren. And the versatility? Kendeigh (1941: 23) tells us that when females arrive, the time of most energetic singing, the bird "intersperses" its territory song with the mating song. Timing with a stop watch, as carefully as possible, one giving 9 songs a minute, I got a spread of lengths even greater than Saunders gives for the species as a whole. I cannot think that more than half of this variability was due to my inaccuracy. Also, on the Cornell Recordings of American Bird Songs, Volume II, slow playing and careful listening disclose at least one definite variation in one of the four songs, which I think came from one individual. Bewick's Wren (*Thryomanes bewickii*) sometimes sings somewhat continuously, up to 18 times per minute (Miller, 1941: 88), averaging 10. Fish (1953: 254–255) made an instrumental analysis of a series of songs from an individual singing 8.7 songs per minute with an average length of 2.4 seconds, barely semi-continuous. Fish found the songs identical, except for "detailed variations" in the couplets (4 to 6) forming the third or last part. The Nices (Nice and Nice, 1931), however, report 10 "different types of song from one individual." The remaining wrens in North America, I believe from experience, all fit well into our scheme.

Two great American groups consist largely of highly repetitious singers which, as our theory requires, are also highly discontinuous: the "sparrows," finches of the subfamily Emberizinae, and the wood warblers or Parulidae. In most cases they have short set songs which are merely reiterated, at least in any one usual performance of a few minutes. Rates are as a rule between 5 and 7 per minute, with a maximum of 9 or 10, which, with the brevity of the songs, means a usual continuity of about 20 and a rarely exceeded maximum of 30 per cent. Exceptions are instructive. Thus the Lark Sparrow (*Chondestes grammacus*) is in my experience the most continuous singer in either of the two groups, and it is easily the most versatile. Saunders (1951: 301) says: "A bird sings one song after another, no two of them alike." He recorded 6 different songs from an individual, each occurring but once, and during this time others were sung that he lacked time to record. The versatility of Bachman's Sparrow (*Aimophila aestivalis*) is well-known, but definite information concerning its continuity is lacking. Descriptions of the Brewer's Sparrow (*Spizella breweri*) imply marked continuity *and* variety (Hoffman, 1927: 331; Swarth, 1930: 255–56). The Song Sparrow (*Melospiza melodia*) of course has wonderful variety (6 to 24 songs in each

individual repertoire), but of the eventual kind only, each song being sung a number of times—on occasion as many as 70—before another is used (Nice, 1943: 124). In a "highly stimulated state," a singer may reach 10 times per minute, using the same song for two or three minutes (p. 115). This is semi-continuous singing (45 per cent); the cumulative approach to monotony, one may surmise, causes the bird to draw on his repertoire, whereas a species without this recourse, but otherwise comparable, must gain more complete refreshment from slightly longer pauses as he goes along. Mrs. Nice (1943: 122) gives evidence to show that birds in the prime of life repeat a song more times than old or young ones: there is "sustained effort." Effort implies resistance, the inhibiting tendency of unrelieved repetition. Perhaps the most problematic of the finches, from our point of view, is the Dickcissel (*Spiza americana*) which appears to reach semi-continuity (Nice and Nice, 1931; Saunders, 1951). However, an individual probably varies the number of "dicks"; also this is one of those species that is subnormal *both* in variety (or adequate pauses) in the succession of utterances, *and* in musical contrasts within each utterance.

Many wood warblers are typical repetitive-discontinuous songsters. The Black-throated Green (*Dendroica virens*) sings from 5 to 8 times per minute (Nice and Nice, 1932: 169–71); and many others similarly space out their brief and relatively unvarying songs—as I have observed at various times of day and season in Northern Michigan.

In sharp contrast is the Yellow-breasted Chat (*Icteria virens*) the most consistently continuous, or near-continuous, singer in the family, and the only consistently versatile one. Usually 7 different phrases, in no fixed order, are used (Bent, 1953: 593) at a rate of 10 phrases in 25 seconds (Saunders, 1935: 213). Phrases are short, giving a continuity of perhaps a little over 40 per cent. Considering the extreme simplicity of most of the phrases, versatility seems also medium high. The American Redstart (*Setophaga ruticilla*) is noted for its versatility; in Cheboygan County, usually at dawn, I have often heard it singing 12, and sometimes 13, 15, or even 17 times per minute, also 9 times in 30 seconds. The last three rates, which constitute semi-continuous singing, were from the same individual, to judge by the location and the most distinctive of the songs. I *saw* this individual sing 12 times in a minute at 10:50 A.M., July 14. I think there is no mistake about the 15 and 17 counts: had I been taking two birds for one I should have gotten 19, 20, or more, since it was the energetic dawn singing, when no rates below 10 were obtained. These high rates were with conspicuously versatile singing,

although, as Saunders (1935) remarks, Redstarts sometimes sing the same song over and over. When they do so, the rate is generally 7, 8, or 9, occasionally 10 or 11; but when they (irregularly) "alternate" two or more songs, the rate, while sometimes low, is more commonly 9, 10, 11, sometimes 12, and up to at least 17 per minute. Thus the average for versatile singing seems about 2 and the maximum about 5 songs per minute, higher than for repetitious singing. Moreover, a bird has several times shifted, as I listened to him, from repetitious to versatile, or from versatile to more versatile singing (by the addition of one or two more songs to the shuffle back and forth), and therewith the rate per minute has also risen. Thus my 17-a-minute bird once, late in the morning, sang five times in one minute, using two songs, but then added a third, his most distinctive song, by which he could be recognized, and sang 8, 12, and 11 times during the following three minutes. (Perhaps he saw me and got excited.) Another observer, James M. Hartshorne, watching the nest from a blind heard six distinct songs from this individual, probably an unusual one both in versatility and in continuity. When Redstarts sing repetitiously, they are apt to give the song a kind of finale (Saunders, 1935)—as though to emphasize the separateness of each utterance, the lack of continuity! One such song sounds like, "see, see, see—Splash!" Time a bird singing exclusively like this, and you are not likely to get a rate higher than 9 a minute. Sturm (1945: 191) gives only 9.6 for "short intervals of active singing": this, I presume, was an average for a number of minutes; otherwise I cannot understand his getting no higher rate for the species, and even then it seems dawn singing must have been omitted. Or is a remarkable regional difference involved?

The two types of singing, repetitious-discontinuous and versatile-continuous, are illustrated even more clearly by the Canada Warbler (*Wilsonia canadensis*). Kendeigh (1945: 159) mentions a rate of six songs per minute: in mid-June, 1954, two individuals near the Station sang quite repetitiously at this very rate; and at the same spot in early July one sang eight times per minute, also without variations. On other occasions of unvaried singing the rate has been no higher. Yet one of the two heard in June began, before I left, to sing with obvious variety at a rate of eleven per minute, which is semi-continuous singing (songs 1.8 seconds). This renewed my confidence in a recollection from the previous year of an individual of the species at this spot singing once about every four seconds, using several contrasting songs. Toward the end of June, I managed to get to the swamp edge at or before sunrise. A Canada rewarded

me with almost fully continuous and amply versatile singing—9 times in 30 seconds and maintaining approximately this rate for several minutes, chipping or "tsacking" rhythmically between songs. I have heard no other species of warbler sing so continuously, nor—considering the complexity of the songs—so versatilely. The versatility has been noted by Saunders (Bent, 1953: 652) and the continuity by Allen (Bent, *loc. cit.*). What has not been noted is the sharply dual personality of the bird, combining two very different modes of singing.

The cardueline finches, for example, the Goldfinch (*Spinus tristis*), are fairly continuous and likewise fairly versatile singers. (The very different European Goldfinch also has both continuity and variety.) The Purple Finch (*Carpodacus purpureus*) has a tendency toward continuous singing (Saunders, 1935), and when indulging this tendency it also practices systematic variations on its rather complex song, as one could observe from the doorway of Blanchard Laboratory at the Biological Station. The method is to break the song into fragments, and string these together with the full song in various delightful ways. The Holarctic Pine Grosbeak (*Pinicola enucleator*) is reputed by various American and European authors to sing both continuously and with variety.

The cardinal grosbeaks and their allies are in much the same class, especially the Cardinal (*Richmondena cardinalis*), a species which seems intermediate between the eventually versatile and the immediately or fully versatile types. An individual practices variations upon its groups of slurred notes (Saunders, 1935: 241), but there is a tendency to reiterate each group a number of times. The continuity seems also intermediate. The Rose-breasted and Black-headed grosbeaks (*Pheucticus ludovicianus* and *melanocephalus*) have moderately complex songs with somewhat short pauses, and Saunders says of the first that an individual sometimes varies the last half of its song.

The family of troupials, Icteridae, has in the United States no highly continuous singers. It also has no highly versatile ones, except the two meadowlarks (*Sturnella*) but these employ their versatility in the eventual manner. The western species (*S. neglecta*) has more notes and stronger contrasts in each song, but apparently no such number of diverse songs as Saunders has found in repertoires of the Eastern Meadowlark (*S. magna*), and hence it may be comparable in versatility. The Bobolink (*Dolichonyx oryzivorus*) achieves a certain variety, partly through the "strumming" of its sometimes banjo-like instrument or singing of small song-fragments between full songs; and its pauses are often rather short pauses for the length

of its song. A typical repetitious-discontinuous singer, on the other hand, is the Red-wing (*Agelaius phoeniceus*). The orioles (*Icterus*) have comparable pauses and perhaps a bit more variety.

Among the true songbirds known to me, perhaps the most marked apparent exceptions to the generalization, "no highly repetitious highly continuous singing," are the Chipping Sparrow (*Spizella passerina*) and the White-breasted Nuthatch (*Sitta carolinensis*). In these cases a rather unmusical two-note phrase (not clearly discernible as such to the human ear because of speed or slurring) is reiterated; and the reiterations are definitely grouped into series of rather variable length constituting "songs." Pauses between songs may be of discontinuous magnitude, but the Chippy in early morning may use pauses "as short as or shorter than the song" (Saunders, 1935); and I have heard the Nuthatch singing, as near as I could tell without a stop watch, 40 per cent of the performance time. The lack of a fixed number of phrases in each song and the variations in the length of pauses, constitute the only versatility. The fact that the basic simple phrase is merely repeated means that the procedure can be carried out automatically, as in the act of walking or flying, while attention is largely elsewhere. The Chippy, at least, sings with little intensity compared, for example, with the Ovenbird. In both cases, the lack of what seems adequate contrast (or pauses) between successive utterances of the phrase matches the poverty of well-defined variety within the phrase.

More drastic "exceptions" to our anti-monotony principle occur outside the oscinine suborder and are more extreme cases of the same characteristics. Thus the Least Flycatcher (*Empidonax minimus*) in the early morning repeats an unmusical "ti-beck" or "chebec" almost without substantial pauses, though not without slight modulations of rhythm, hundreds of times. It is a species which lives about clearings, pairs being close together and in fairly good view of one another. Probably sight is playing a greater rôle than in the typical singer. Nor, so far as I know, has it been ascertained that the "song" is more than a "position call" for the mate, in which case it need not have constantly high stimulus value, for performer or listener. If the mate needs, at any time, to know where the bird is, it has only to listen. The Eastern Phoebe (*Sayornis phoebe*) sings a dawn song consisting of two mildly contrasting phrases, alternating irregularly, "phoebe" and "phoebleet." It is a musically dull performance, in the themes as well as in their excessive reiteration, yet in both respects superior to the Chebec. And I have heard what I took to be a song duel between rivals. In sharp contrast to

the foregoing egregious repeaters is the most musical non-oscinine species in North America, the Eastern Wood Pewee, which excels not only in the musical sweetness and effective contrasts within and between its three principal phrases, but also in the optimal variety, as already pointed out, in the order of their occurrence.

The Whippoorwill (*Caprimulgus vociferus*) has a *slightly* musical phrase (slow playing of a record does not improve one's opinion of it, as it does with many species) of five notes (the human ear misses two), and this phrase is repeated, sometimes hundreds of times, in fairly quick succession. The arrangement of the three chief pitches, 2-1-3, that is, a fall and a sharp rise, seems to call for the drop to the opening note as the tonic, and so the thing seems to keep itself going musically with almost hypnotic effect. In this case, and in that of the Chebec, there is some rhythmic modulation, the bird pausing ever so slightly here and there, making a break in the mechanical precision of repetition.

It may be no accident that such continuous reiteration occurs chiefly, if not exclusively, in sub-oscinine species and not commonly even there. A slightly lower order of sensory-emotional sensitivity, not just of vocal organs, is probably involved.

However one views the seeming exceptions to the rule against repetitive continuous singing, in the main the rule stands. This could, I think, be shown for other families than those considered and for other parts of the world. The exceptions are probably merely extreme or limiting cases, songs of such meager musical content that they are little more than definitions of rhythm, their slight variety (which may well be more apparent to the birds—with their faster tempo—than to us) consisting in changes in the number of notes between pauses and in the length of the pauses. Such songs are rather rhythmical frames for a pattern of activities, than a pattern important in itself. A Vesper Sparrow's song, to take a contrasting example, is too complex and intense in musical form to function readily in this secondary manner.

To consider the possible reasons in the respective life-cycles for the modes of singing of various species, whether versatile-continuous, repetitious-discontinuous, or eventually varied and discontinuous, lies beyond the scope of this article. Such reasons do not, in general at least, suspend the sway of the anti-monotony principle opposing the union of continuity and repetitiousness.

The most basic conclusion from the evidence presented is perhaps this: birds, like ourselves, though in their own very limited fashion, are subject to the great principle of beauty, "unity in variety." (See

Saunders, 1929: 125–131; Craig, 1943: 67–69, 144–177.) Song may have developed from simple calls and/or random warbling to more complex and definite patterns whereby contrast is sharpened and made more effective; such patterns are then repeated, either with variations or at intervals long enough to allow the fading of vivid memory. Rarely indeed are patterns simply repeated over and over with scant pauses. This avoidance of mere repetition is what the principle of beauty demands, equally with the avoidance of mere change.

Although such views may seem "anthropomorphic" to some readers, will they not to others seem the logical way to include human reactions within the biological scheme? Man (especially in his non-verbal reactions) is not wholly unprecedented in nature; his traits have more or less primitive analogues in the lower orders. One such analogue has been the subject of this paper.

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SUMMARY

1. Variation, both of behavior and of stimuli, is a biological necessity. This explains many facts about bird songs.

2. Song-behavior has gradations of "versatility" and of "continuity": the first concerns the number of different songs, variations, or phrases, and the extent of contrast between them; the second is the ratio between the amount of singing in seconds, and the total "performance period" as inclusive of "substantial pauses," if any.

3. Discontinuous singing (pauses over 70 per cent) need not be versatile, for (it is argued) the pauses exceed the span of vivid memory; singing lacking versatility and yet highly continuous (pauses less than 50 per cent) is least likely to escape the "monotony-threshold," and hence not likely to occur. Actually it is rare.

4. The threshold is a variable, depending inversely upon level of nervous organization. Indicative of a low level—a high threshold, great tolerance for monotony—is a lack of clear musical contrasts within the basic song pattern, as well as in its reiteration without ample pauses or variations. The second deficiency is found only in association with the first.

5. Families in which continuous singing prevails—thrushes, thrash-

ers, vireos—are also prevailingly versatile; the prevailingly non-versatile groups, Parulidae, Emberizinae, are prevailingly discontinuous, and the few continuous members of these are also the most versatile. Groups or species intermediate in one respect are intermediate in the other.

6. "Exceptions" are few and not inexplicable in terms of the same principles.

7. Song-development exhibits a trend toward "unity in variety," i.e., beauty, which is to be expected if human nature is a further unfolding of tendencies pervading all life.

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2075 Ridgewood Drive, N.E., Atlanta 7, Georgia, September 13, 1954.

OBSERVATIONS OF A NESTING COLONY OF AMERICAN BRANT

BY THOMAS W. BARRY

THE AMERICAN BRANT (*Branta bernicla hrota*), an important game species on the Eastern Seaboard, suffered great declines in the 1930's. For some time, the brant population has been known to fluctuate considerably from year to year. Presumably arctic storms on the nesting grounds cause declines in some years. Its numbers also have been reduced by encroachment of civilization, increased commercial navigation, oil pollution, over-shooting, and especially by the disappearance of eelgrass (*Zostera marina*), the bird's staple winter food. Cottam, Lynch, and Nelson (1944) reported that the American Brant population dropped in 1933–1934 to 10 percent of the 1930–1931 figure as a result of eelgrass destruction.

In the Boas River area of Southampton Island, NWT, in the summer of 1953, there existed approximately 700 nesting pairs of brant and 400 yearlings. This indicates a tremendous increase in the last two decades. Manning (1942) reported only two nests in 1934, and Bray (1943) saw eleven in 1936. This increase may have taken place at the expense of another colony, but perhaps comparative studies of other brant colonies in the Eastern Arctic will show a widespread increase in numbers.

I was able to study the 1953 brant colony on Southampton Island while accompanying F. Graham Cooch of Cornell University (now of Canadian Wildlife Service), who was studying Blue and Lesser Snow geese (*Anser caerulescens*). I wish to acknowledge the kindness of the Air Transport Service, RCAF, and the Department of Transport, Canada, for making the air trip possible.

The western coast of Southampton Island, facing on the Bay of God's Mercy, is a low, level tidal-plain tundra. The brant colony was centered in the mass of islands in the two-mile-wide delta of the Boas River and thinned out to the east and west for four and one-half miles. This brant concentration was entirely separate from the Blue and Snow geese which nested at least one-fourth mile inland from the high tide line. The area corresponded almost exactly to the brant nesting area described by Bray (1943).

The islands, averaging about one foot above high tide, were as small as six feet across and as large as two acres. They were covered with very short thick grass, sphagnum, or limestone gravel. Some were strewn with kelp washed in by fall storms.

Weather here was marked by strong and unrelenting winds and

by alternating periods of approximately seven days of sunshine and seven days of fog, rain, and snow. The highest temperature was 62° F on July 7, but the average was near 35° F in June and 45° F in July.

The brant were the last birds to return to the Boas River to nest. They began to arrive June 8, ten days earlier than the arrival noted by Sutton (1932). They flew in low over the bay ice from the east

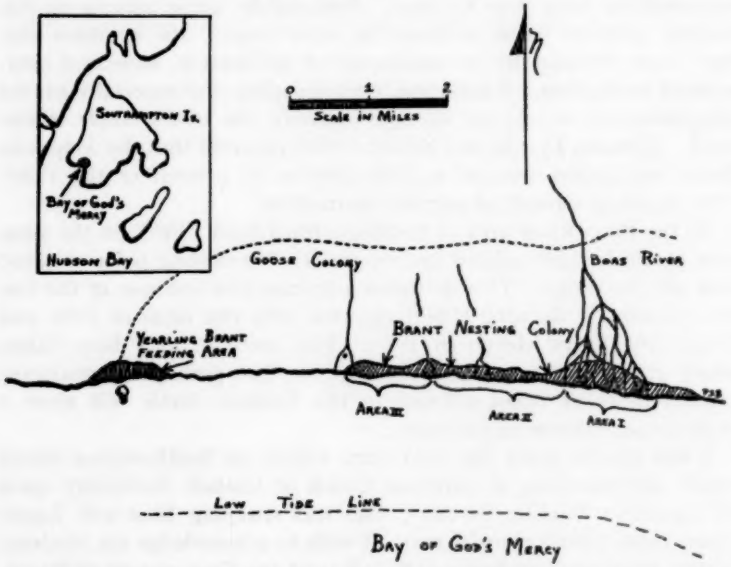

FIGURE 1. Sketch map showing the location of the Boas River brant colony, Southampton Island.

along the coast, or from the southeast from the direction of Cape Low. Probably they had followed the migration route described by Lewis (1937): passing the James Bay region after an overland flight from the Gulf of St. Lawrence, thence north along the east coast of Hudson Bay late in May, and branching off toward Mansel, Coates, and Southampton islands, north of Cape Smith.

The nearest Southampton landfall to Coates Island is Cape Low. Harry Gibbons, a Southampton Eskimo, told me that brant flew north past his camp at Gibbons Point (situated halfway between Cape Low and the Boas River delta).

From June 8 to June 13, brant arrived in small flocks of seldom more than 20 birds. Most individuals were in pairs on arrival. The

nest islands were still extensively covered with ice and water, and the brant congregated in run-off pools to await favorable conditions. As the islands cleared, pairs would leave the flocks and set up nesting territories. Unavailability of nest sites may account for the lateness of the brant arrival, compared with that of the Blue, Snow, and Hutchins geese (*Branta canadensis hutchinsi*) that arrived about 10 days earlier. Sabine's Gulls (*Xema sabini*) and Arctic Terns (*Sterna paradisaea*) also nested along the edge of the tide flats, and they, too, were among the last birds to arrive. The Eskimos said, "when nucklingnok (brant) is here, all are here." (See Phenology Chart.)

Since most of the brant arrived paired and ready to nest, little activity was observed that could be described as courtship. Sutton (1932) believed brant arrived unmated at Southampton Island, but he did not elaborate his theory. However, on June 17 and 20, I witnessed what appeared to be a courtship flight among the few brant that were unmated on arrival. My notes read: "Two birds appeared to be vying for position just behind and close to a third lead bird (female?). They skimmed fast over the water and islands, flying so low their long pointed wings seemed to touch the water. Then all three birds swooped up 50 to 75 feet, turned, and banked. During this maneuver, they winged over almost on their backs but always righted themselves without executing a complete roll. Then, with increased speed, they dipped low again and repeated the performance. At times they flew so close to each other that their wing beats seemed to hesitate for split seconds so as to avoid collision. Finally, at the top of one flight rise, the last one peeled off from the formation and left the other two to continue the tactics for a while."

The first nest, with one egg, was found June 16. Like the majority of brant nests in the study area, it was on a small island that was covered with a brown grass (probably *Puccinellia phryganodes*,—Polunin, 1940), very short and thick like that of a golf course green. The nest was a hollow in the ground, soupbowl shape, about 9 inches across and 2 inches deep. The permafrost was 4 inches below the nest at the time. The nest itself contained a sparse amount of grass that had been pulled up from within two feet of the nest. The amount of down in it was increased with each successive egg, until a thick, cohesive mat engulfed the clutch. The down was more luxuriant than that of the King Eider (*Somateria spectabilis*) that nested in the area.

The brants' techniques of nest defense appeared comic despite the seriousness of the birds' intentions. Territories were maintained by bluffing, rather than by out-and-out fighting—a marked contrast

to the knock-down tumbling battles of the Blue and Snow geese in their more crowded colonies. When an unwanted pair of brant invaded a neighbor's territory, the resident male and female set up a clamor of scolding "cronks" and poked their necks forward, bobbing their heads this way and that. This was followed by a charge. The defenders would thrust their long necks forward, holding their heads a few inches above the ground, and make a running dash at the intruders. One pair chased two other brant into the water in this way, and, continuing the escort, swam with their necks still extended and their heads about an inch above the water. In this manner they swam on either side of the trespassers for a distance of 60 feet until they came to a small island where the escort was discontinued.

During egg laying, brant remained within 100 yards of their nests, quite different behavior from that of the Blue and Snow geese which ranged much further from their nests during this period. Whenever a female brant left her nest, she covered the eggs with down.

Herring Gulls (*Larus argentatus*) and Parasitic Jaegers (*Stercorarius parasiticus*) were the most notable predators of brant eggs and young. The common practice of a jaeger was to let a gull rob the nest; then the jaeger robbed the gull. Jaegers also robbed nests directly. When jaegers or gulls appeared in the area, the brant flew quickly to their nests. They would then protrude their necks and heads in the characteristic fighting attitude and constantly maneuver to face the predators making passes at the nest. On one occasion, two jaegers set up a figure-eight flight pattern of attack on a pair of brant (a method similar to jaegers' attacks on gulls at a goose nest). The two brant stationed themselves on opposite sides of the nest, each facing one of the diving jaegers. Both remained on guard in this way until the marauders gave up.

Often during the incubation period I observed brant, presumably the males, fly at gulls and jaegers in attacks similar to those of Ruddy Turnstones (*Arenaria interpres*), Arctic Terns, and Sabine's Gulls. One brant put on a surprising display of speed and agility in chasing a jaeger through a sharp climb and several turns. Usually the brant took a good start and flew at a gull or jaeger, "cronked" a a few times and then returned to the nest. On several occasions male brant flew up to meet a pair of trespassing neighbors and escorted them through the nesting territory.

When Polar Bears (*Thalarctos maritimus*) wandered through the nesting colonies the brant paid no attention. This was notable in view of the excited reactions of brant to gulls, jaegers, and humans. Snow Geese exhibited similar calm during intrusions by the bears. Apparently bears do not molest the birds.

Thirteen nests were found early enough to allow daily checks. The first egg was found June 16; the last on June 25, indicating a ten-day laying period. Generally one egg was laid each day, but in eight of the nests one day was skipped during the laying period. In five clutches, the skipped day occurred between the third and fourth eggs, and in the other three clutches, between the fourth and fifth eggs.

In the study area at the west end of the colony, 17 nests had a total of 75 eggs, an average clutch size of 4.41. Of these, eight eggs or young in two nests were abandoned when a sled dog ran loose in the area. The fate of the remaining 67 eggs was: sterile, 6; missing (presumably taken by gulls or jaegers), 4; abandoned nest, eggs or wet young, 5; young leaving nest under natural circumstances, 52.

Twelve nests were available for incubation checks. Counting from the day after the last egg was laid to the day of hatching as incubation time, 10 of the 12 nests required 24 days; one, 25 days; and one, 23 days. From 24 to 48 hours were required for all the young to hatch, dry, and leave the nest.

Once incubation began, the female made herself as inconspicuous as possible. She rested low and flat on the nest, stretching her neck out on the ground. On the islands strewn with dried kelp, she was difficult to discern.

The female generally remained motionless in this flat position until approached at 20 to 30 feet. She would then get up and walk away from the nest, calling repeatedly. At that point, the male would fly up and escort her away. They usually walked together 25 or 30 yards, calling and stretching their necks. Often they would then fly and circle back to the nest. I rarely saw a brant fly directly from the nest when disturbed.

When off the nest, the female fed and preened vigorously while the male stood guard. When re-approaching the nest, the female fed almost continuously on the short grass, bill pointed straight down and pulling grass rapidly. When within five feet of the nest, she went through the routine of picking up nest material and tucking it behind her—false nest building, false eating, and yawning.

The male usually ceased escorting the female when within 15 feet of the nest. Once the female was on the nest, the male would go off 50 to 100 yards to feed and watch.

Unlike some of the Blue and Snow geese, male brant were never observed standing closer than 15 feet from a female on the nest. Generally the male did stay close to the female while both were away from the nest or when predators were active.

Clutch sizes for the entire brant colony were taken from June 27

to July 1 when all egg-laying in the study area had ceased. Clutch size data are separated into three groups from three nesting areas. Area I, the Boas River delta islands, was also the center of Herring Gull nesting. Area II, just west of the delta, had fewer nesting gulls. Area III, 4½ miles west of the delta was the western extremity of the brant colony and was my daily study area. There were no Herring Gulls nesting there.

In Area I, the average clutch size of the 119 nests was 3.77; in Area II, average clutch size of 67 nests was 4.21; in Area III, average clutch size of 17 nests was 4.41. Range and distribution was:

	Area I		*Area II*		*Area III*	
Number of Eggs	*Number of Nests*	*Total Eggs*	*Number of Nests*	*Total Eggs*	*Number of Nests*	*Total Eggs*
1	5	5	0	0	0	0
2	5	10	3	6	1	2
3	33	99	8	24	1	3
4	47	188	28	112	6	24
5	28	140	28	140	8	40
6	0	0	0	0	1	6
7	1	7	0	0	0	0
	119 nests	449 eggs	67 nests	282 eggs	17 nests	75 eggs

It can readily be seen that the apparent mean clutch size increases as the colony spreads out toward the western limits. This could be influenced by several conditions: (1) crowding in the center of concentration on the river delta islands; (2) high water causing a later nesting and therefore incomplete clutches by June 27; (3) unequal number of nests sampled; (4) incidence of Herring Gull nests.

Without discounting the importance of the other possibilities, I believe the presence of Herring Gulls was the primary cause of smaller clutch. Manning (1942), describing gull activity in relation to Snow Geese at the delta islands in 1934, said: "Many herring gulls nest in the colony, chiefly on large glacial boulders. Whenever my passing disturbed a goose and caused it to leave its nest, a gull would swoop down to examine it, and, seeing the eggs, alighted close by. . . . That the gulls do account for large numbers of eggs was shown by the pecked ones scattered about the colony." This activity applied to the brant, which in 1953 were more numerous than during Manning's visit. Manning speculates that many of the pecked eggs may have been abandoned previously by the parent geese, but it was my experience with the brant, that the gull-destroyed eggs rarely had been abandoned.

In the river delta, I saw 50 Herring Gull nests, built prominently on granite boulders strewn about the area. The gulls raided the

brant and goose nests heavily. I watched a lone female brant stand guard over her nest as 15 gulls dove and screamed at her. The brant stubbornly refused to be driven off. When I inspected the nest there were only two eggs. She had lost her mate, and without help guarding the nest, her clutch had been vulnerable to frequent raids.

The first brant egg in the study area pipped July 11, and the last hatched July 21. Incubation time averaged 24 days. Brant with wet young or pipping eggs left the nest hesitantly at my approach. Because they had grown accustomed to me, the parent birds made no attempt to call off the dry young when I disturbed them. I watched one pair return to the nest after I went off some distance; the female settled down on the two dry young and three pipping eggs. But when disturbed by sled dogs, the brant hurriedly departed with those young that could walk and abandoned the others.

Many brant hatched and left their nests at the height of a storm of fog and wind-blown rain on July 18. They appeared to survive the foul weather without mishap.

As soon as the young were dry, the adults stood 10 feet or so from the nests, and, poking their heads and stretching their necks, emitted a long series of "cronks" that kept up five minutes or more. The young were led off to the outer edge of the mudflats, apparently to feed on larvae and small crustaceans. The parent birds would take positions at either end of a string of young and guide them. Several times I saw six or eight brant with 10 or 14 young swimming offshore at high tide, obviously several families flocked together.

Adult birds did not go into molt until the last ten days of July—about a week after the young had hatched. While molting they remained with their young along the tide line and in the tidal pools where food was plentiful and the water calm.

On July 15, the two sled dogs were loose after a Polar Bear and caused a pair of brant to abandon three of four young. The pearl-gray young were placed in a kerosene incubator. Three days later, another abandoned young brant was added. The four captives fed very well on chick starter pellets. When allowed to roam the camp area they fed on mosquitoes and larvae, short grass, and flowers of *Ranunculus*. They took to the water without hesitation and dove, swam, fed, and frolicked. Wild young observed at the same period appeared to be developing at a comparable rate. By July 30, the captives had pin feathers along the base and trailing edge of the wings. In the next two weeks they doubled their weight. On arrival at Coral Harbor they took a strong liking to the *Equisetum*

available there, and as a replacement for chick starter pellets, they fed on Red River cereal, and, to a lesser extent, on corn meal. Later, at Delta Waterfowl Research Station they ate the station's standard pellet ration, barley, and greens.

The non-breeding yearling brant returned to the colony with the adult breeders. However, they remained quite separate from the nesting flock. At about 6 A.M. each morning throughout the season, I observed some 200 brant, in flocks of 40 to 50 birds, flying west along the shore toward a feeding area 9 miles from the colony at the river. In the evening similar flocks would return. The Eskimo boys collected three birds from these flocks; all were yearlings. At the feeding area, I saw yearling brant eating the same type of short grass that covered the nest islands. No nests were found in this area; there was very little open water and no small islands like those further east.

By July 4, fewer brant were making the daily flight to the west. By July 10, the daily flights had ceased altogether as the yearlings had begun to molt. On July 24, far out on the tide flats I saw three yearlings that could fly again. From the vantage of a large boulder, I observed the large flock of yearlings in the bay by the river, where they had congregated for the molt.

Early in the season brant feed on tender grass shoots under the edges of kelp drift. Later, adult and yearling brant feed almost exclusively on the short grass found on their nesting islands. Stomach contents yielded nothing else. Young Blue and Snow geese also fed extensively on this grass. There is apparently no eelgrass growing in this area.

Although I left the brant colony August 3 and did no banding, the young should have been large enough to band by the end of the first week in August. The driving and corraling of flightless geese described by Cooch (1953) could be employed with brant to some extent, but the driving would have to be partly or entirely amphibious, depending on whether adults and young along the shore, or molting yearlings offshore are to be banded in numbers.

Sutton (1932) considered the Arctic Fox probably the worst enemy of Southampton Island brant, and he minimized the importance of gulls and jaegers. I found the opposite was true on my study areas, which were generally wetter than the areas Sutton observed. As mentioned before, gulls take heavy toll of brant eggs and young in the Boas River. Foxes are not a problem here, because they vacate the wet lowlands when the thaw begins. Hunting and egg collecting by Eskimos are negligible because of wide dispersal of brant nests

compared with the concentration of Blue and Snow goose nests, and because brant here at this time have a strong muddy flavor. At any rate, they do not resemble the savory meal brant affords when shot further south (Bent, 1925).

Of greater importance to brant management than protection from predation is improvement of food supply. While the species has been able to adjust somewhat to changing food conditions, the Report on Bird Protection of the A.O.U., 1939, reveals that Atlantic Brant are increasing as the once-threatened eelgrass regains lost ground.

Porsild (1932) states that *Zostera marina* occurs as far north as Cape Eskimo (Eskimo Point) and that it requires about 15° C to vegetate. The plant appeared to survive the action of ice in sheltered areas. It may well be worth investigating the possibilities of its succeeding off the mouth of the Boas River where the water may be warmed by waters flowing from the interior.

PHENOLOGY CHART

(First dates seen, with numbers)

1953, Boas River, Southampton Id., NWT, Canada

May 26	Our arrival—area 85 per cent covered with snow and ice	
	Willow (*Salix arctica*)	catkins
	Herring Gull (*Larus argentatus*)	20
	Whistling Swan (*Cygnus columbianus*)	4
May 27	Sandhill Crane (*Grus canadensis*)	1
	Snow Bunting (*Plectrophenax nivalis*)	20
	Lapland Longspur (*Calcarius lapponicus*)	50
May 28	Redpoll (*Acanthis flammea*)	25
May 29	Lesser Snow Goose (*Anser caerulescens*)	13
	Blue Goose (*Anser caerulescens*)	1
	Hutchin's Goose (*Branta canadensis hutchinsi*)	2
May 30	Sabine's Gull (*Xema sabini*)	2
	Sanderling (*Crocethia alba*)	2
	Red-backed Sandpiper (*Erolia alpina*)	2
May 31	Ruddy Turnstone (*Arenaria interpres*)	2
June 1	Red-throated Loon (*Gavia stellata*)	1
June 2	Parasitic Jaeger (*Stercorarius parasiticus*)	1
June 3	Horned Lark (*Eremophila alpestris*)	2
	Red Phalarope (*Phalaropus fulicarius*)	3
	Duck Hawk (*Falco peregrinus*)	1
	American Pipit (*Anthus spinoletta rubescens*)	1
	Pintail (*Anas acuta*)	2
June 4	Raven (*Corvus corax*)	1
	King Eider (*Somateria spectabilis*)	9
June 5	Long-tailed Jaeger (*Stercorarius longicaudus*)	1
	Pomarine Jaeger (*Stercorarius pomarinus*)	2
	Black-bellied Plover (*Squatarola squatarola*)	5

June 6	Golden Plover (*Pluvialis dominica*)	1
	Knot (*Calidris canutus*)	3
	Baird's Sandpiper (*Erolia bairdii*)	2
	Glaucous Gull (*Larus hyperboreus*)	1
	American Eider (*Somateria mollissima*)	11
	Arctic Tern (*Sterna paradisaea*)	4
	Semipalmated Plover (*Charadrius hiaticula*)	5
June 8	American Brant (*Branta bernicla hrota*)	18
	Iceland Gull (*Larus leucopterus*)	1
June 10	White-rumped Sandpiper (*Erolia fuscicollis*)	5
June 16	Semipalmated Sandpiper (*Ereunetes pusillus*)	2

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COMPASS DIRECTIONAL TRAINING OF WESTERN MEADOWLARKS (*Sturnella neglecta*)

BY URSULA VON SAINT-PAUL

EXPERIMENTS at Wilhelmshaven, Germany, have demonstrated that a number of bird species are able to orient themselves by means of the sun's azimuth. The first step in these experiments was the observation that caged Starlings (*Sturnus vulgaris*) exposed to a clear sky at migration time strove to go in the general direction of migration. The sun was clearly indicated as the orienting factor in those easily observed migrational motions (Kramer, 1950a). At the same time, it was clear that the bird was able to correct for the sun's movement during the day.

As the migration activity drives the bird to choose a given visible direction for only a short period, it was considered desirable to devise experiments which were not dependent upon the migratory urge. Therefore a method with food as reward was used for directional training.

An ability to estimate the time of day must be an essential part of the complete mechanism of sun azimuth orientation. The "internal clock" on which the bird relies can be experimentally set back or ahead (Hoffmann, 1954). As a consequence, the direction chosen by the bird is changed by an amount which corresponds quantitatively to the length of time by which the daily rhythm of the bird was shifted.

There are three possibilities for testing whether or not the birds are orienting themselves by the sun: a) One tests when the sky is entirely overcast. The bird should show confusion. b) One fools the bird, changing the apparent position of the sun by mirrors. The direction of choice should change correspondingly. c) One can set up an "artificial sun" to substitute for the real sun.

By using these methods the following bird species have shown the ability to orient by means of the sun's azimuth regardless of time of day: European Starling (Kramer and v. St.-Paul, 1950); Red-backed Shrike, *Lanius collurio* (v. St.-Paul, 1953); Barred Warbler, *Sylvia nisoria* (v. St.-Paul, 1953), and Homing Pigeon (Kramer and Riese, 1952).

It seemed desirable to experiment with an other species in order to see how general sun orientation ability may be among birds. An opportunity presented itself in Wisconsin in summer of 1954.

Material and Methods.—The Western Meadowlark, an icterid and bird of the American grassland, was chosen for this experiment. Because this bird is quite similar in its manner of feeding to the

European Starling, it was possible to use the same apparatus which had been used for that species. In particular, meadowlarks pry into cracks by opening their bills to look inside as Starlings do. The rubber-covered feeder doors (devised by Kramer, 1950b.) with a slit in the rubber through which the birds poked their bills were well suited to the purpose.

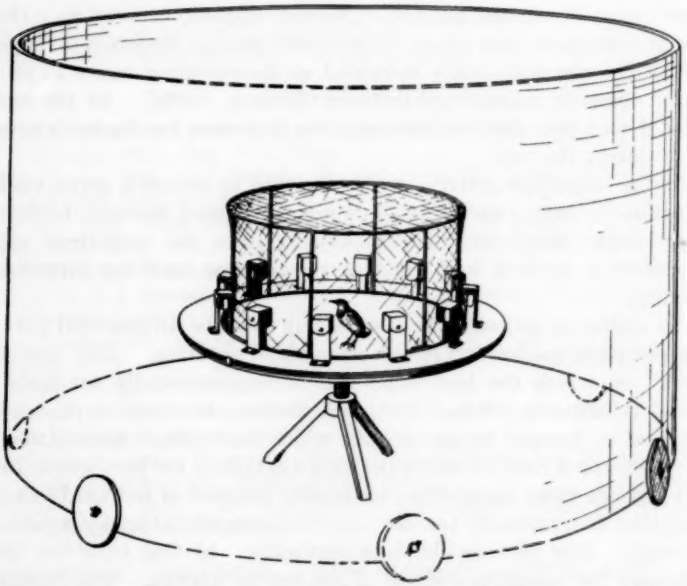

FIGURE 1. Training-cage showing 12 feeders arranged on a lower ring and 12 covers arranged on an upper movable ring. All feeders are covered in the position shown. The circular masonite wall, which excludes landmarks from the bird's view, can be rotated.

The basic procedure consists in conditioning the bird to expect food from one of the feeders which is distinguished by its compass bearing. Directional specificity is built up during the training period and will be obvious by the bird's growing success in hitting the correct feeder. To furnish the final proof, "critical choices" are arranged; these resemble the training choices except for being unrewarded. For obvious reasons the first rewarded choice in each training period is a critical one.

Figure 1 shows the apparatus used. Landmarks were excluded by the circular masonite wall 4 feet high and 7 feet in diameter, which could be rotated on six wheels. The experimental cage was placed in

the center of this cylinder with the multiple choice apparatus on a turntable. The apparatus consisted essentially of twelve feeders which were placed at equal distances on a ring around the cage. On a second ring which was movable there were twelve covers which hid the feeders. To elicit a choice, the bird was given free admission to all feeders by removing the covers simultaneously.

The birds spent most of their time in an aviary and were brought one at a time to the apparatus only for training or testing.

It is essential to have the birds both healthy and tame for training. Therefore eleven nestling meadowlarks, 9 to 11 days old, were taken from two nests and hand-reared. Five of these, two from one nest and three from the other, were subsequently trained. The birds were well fed at all times, except for a short time before each training or testing period when they were kept without food to give them appetite.

The experiments.—The experiments were planned in such a way as to show whether or not time of day was taken in account. An awareness of time can be demonstrated by keeping the training time always within the same brief period each day, then deliberately setting the test periods for another time of day.

Training of the first birds began on July 15, when the meadowlarks were six weeks old. At the start, the birds were trained for half-hour periods. Later, when they had learned to seek food in approximately the right direction, the training periods were shortened to 10 to 15 minutes. After about three weeks, the birds chose the training direction with such certainty that even though the correct feeder and every second feeder contained food, the influence of training was undisturbed. This also establishes that it was impossible for the bird to notice the reward in advance. In this stage of the training—from August 11 on—one or two and sometimes up to four choices without reward were offered before the bird received a reward. Simultaneously tests at other times of day were started. In these, the birds were *never* rewarded.

Of course it was impossible to protract tests without reward unless reinforcement was given during the training period at frequent enough intervals to keep the bird from "unlearning." The birds quickly learned that they could expect no reward except during training periods; sometimes during the tests they entirely refused to choose. So it appeared desirable not to offer more than three tests without reward. However, as the time for this study was limited, up to six choices without reward were sometimes offered, and this may have increased the width of the choice scatter. At least one reinforcement period was interspersed between every two test periods.

Figures 2A and 2B show the critical choices of the training period

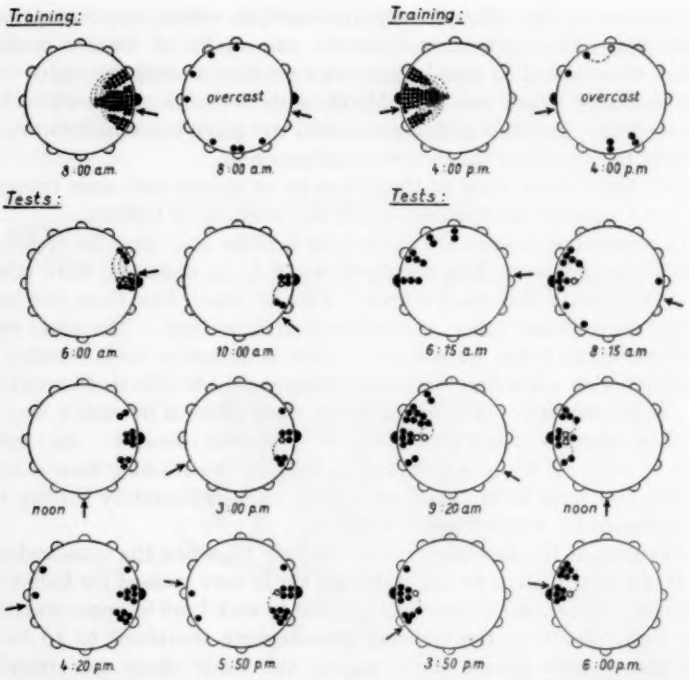

FIGURE 2. Choice diagrams of Meadowlarks 1 (*left*) and 2 (*right*). The arrow indicates the position of the sun. Each semicircle on the circumference represents the location of a feeder. The solid semicircles show the proper feeder of the training direction. Each solid dot indicates a critical choice. If a correction was allowed, these second choices are represented by open dots and connected by broken lines with the incorrect choice.

as well as choices at various test periods for Meadowlarks 1 and 2. Meadowlark 1 was trained to seek food from the east feeder between 7:50 and 8:00 A.M. The training period for Meadowlark 2 was between 3:50 and 4:10 P.M. The diagrams show that both birds held to the compass direction, even when tests were given at different times of day. Only when the azimuth had altered by approximately 180° or more were individual, major mistakes noticeable. Choices were elicited from both birds during periods of overcast occluding the view of the sun during training period. Those choices, shown separately in Figures 2A and 2B, are randomly distributed.

The results with Meadowlark 3 were similar to those with birds 1 and 2. However with this bird, the original training time (8:30 to

8:45 A.M.) could not be strictly adhered to, so that the data obtained from this bird are less valuable. Overcast conditions caused disoriented choices in this bird too.

Meadowlark 4 was trained toward the south at noon, and training was not started until August 17. Training was handicapped by the midday heat and as a result took longer than it did for the other birds. Owing to shortage of time, this bird could only be tested a few times

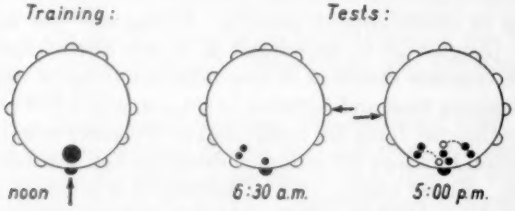

FIGURE 3. Choice diagram of Meadowlark 3. The total of critical choices during the training period is represented by one large dot.

after successful training. These few tests, however, show that this bird too, which was always rewarded in the direction of the sun, maintained its compass direction at times other than noon (Figure 3).

Meadowlark 5, a sib of Meadowlark 2, was trained toward the west between 8:45 and 9:00 A.M. As in the case of the others, the training period from August 11, on, was considered sufficient. The first data are presented in the top row of Figure 4. At 6:50 in the morning the sun's position is not far enough from the position at training time to determine whether the bird was holding to the compass direction or

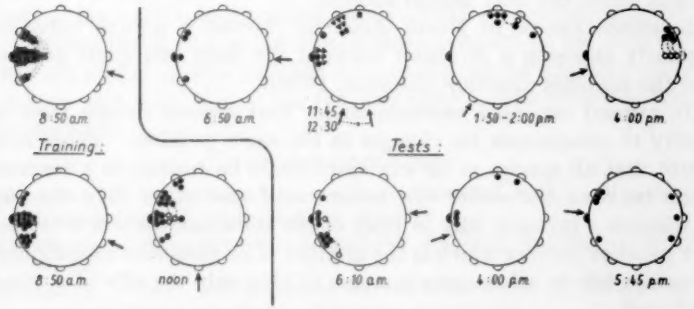

FIGURE 4. Choice diagram of Meadowlark 5. Between 11:45 A. M. and 12:30 P. M., choices during different testing periods are represented by different symbols. At 11:45 A. M. the choices are represented by circles, at 12:00 NOON by triangles, at 12:30 P. M. by squares. For further explanation see the text.

to the sun's actual position. With more drastic changes in azimuth it becomes clear, that this meadowlark held rather to a fixed sun angle than to a given compass direction. However the six choices straight toward the west cause one to suspect that this bird too had the potentiality for compensating by means of time sense but for some reason did not show it in most of the cases. The number of tests at various times of day is unfortunately small, and this is correlated with this particular individual's marked reluctance to make choices outside the training or reinforcement periods. During the last days of the experiment (August 28 to September 4) it was offered food rewards in the same compass direction at two different times of day; namely at the old training time and between 11:50 A.M. and 12:00 noon. The results from this day forth are designated in the lower row in Figure 4. The inclination to adopt the compass direction has now become more pronounced. Either ability, that of holding to a constant angle with the sun or of orienting in relation to the compass direction, could have governed this bird's choice.

Only a few choices could be obtained with overcast conditions from Meadowlark 5. Their distribution was random (not shown in Figure 4).

Discussion.—Among the birds which were examined for their ability to orient by the sun (see page 203), only two individuals, the shrike and one of the pigeons, reacted like Meadowlark 5, orienting themselves sometimes in relation to the actual sun azimuth and sometimes in relation to the compass direction.

Kramer (1952) tried to train a Starling to react to the actual sun direction rather than to the compass direction, and after many weeks, he had some, but only partial success.

Starlings, native in North America, showed a unique behavior, regularly choosing a direction between the fixed sun angle position and the compass direction (Rawson, 1954).

In general one may conclude so far that several species have an ability to compensate for changes in the sun's position. There is no doubt that all species so far examined could be trained to a constant angle between the feeder and some visual clue other than the sun. It remains a mystery why in most of the instances the sun is treated in a peculiar manner which is the product of an elaborate evolutionary process, while in a few cases it seems to play only the rôle of a visual landmark.

Acknowledgments.—This work was supported by financial aid from the Frank M. Chapman Memorial Fund, and I wish to express my thanks to the administrative committee for this fund. Housing and

working facilities were kindly offered by Dr. and Mrs. F. N. Hamerstrom, Plainfield, Wisconsin. I am grateful to Mr. O. Mattson for his help in technical preparations and to Miss E. Hamerstrom for efficient assistance in taking care of the experimental birds. The problem was suggested by Dr. G. Kramer, Wilhelmshaven. Parts of the technical equipment belonged to the Max Planck-Institut für Meeresbiologie, Abt. Kramer. I take special pleasure in acknowledging my indebtedness to Mrs. F. N. Hamerstrom in translating the German manuscript. I am grateful to Dr. and Mrs. F. N. Hamerstrom and to Dr. G. Kramer for critical reading of the manuscript. Many thanks are due to Mrs. L. Dinnendahl, who prepared the drawings reproduced here.

Summary.—Hand-reared Western Meadowlarks were trained by the method used by Kramer to seek food in a given compass direction. The training periods, which never lasted more than 30 minutes, were always at the same time each day. After 20 days of training, critical choices established that the birds had become capable of selecting the compass direction toward which they had been trained. The method used eliminated the possibility that the birds might be using visible landmarks other than the sun. On overcast days the birds were disoriented.

Tests conducted at times when the sun's position was different from that in the training period were to show whether the bird would choose on the basis of a constant angle with the sun's actual position or correct for the time of day and choose the compass direction. In Figures 2A and 2B, are shown the choices made by two individuals which selected the compass direction independently of the time of day. One out of five meadowlarks (Figure 4) usually chose on the basis of the sun's actual position, not allowing for its daily movement.

The results of this study give further support to the supposition that the ability of true azimuth orientation, where the sun's azimuth position and time of day are the necessary requirements, is general among birds.

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Max Planck-Institut für Meeresbiologie, Wilhelmshaven, Germany, May, 1955.

VARIATION IN CAROLINA WREN SONGS

BY DONALD J. BORROR

THERE is a great deal of variation in the songs of the Carolina Wren (*Thryothorus ludovicianus*), but the extent of this variation is not well known. Many writers speak of the "large number of different songs" any individual bird may sing but make no statement of the exact number. A. A. Saunders, who possesses an exceptional ability to analyze bird songs by ear, reports (Bent, 1948: 213) hearing 8 different songs from one individual in less than half an hour and 36 different songs from one individual in the course of one season. I have seen no definite statement as to whether or not two different individuals may sing identical songs.

The accounts of Carolina Wren songs in the literature are based on auditory analyses and, considering the complex rhythms of these songs and the rapid rate with which they are uttered, it is not surprising that so few writers have attempted to give an exact account of the variation in them. However, the difficulties in studying the variation in bird songs can be largely overcome by the use of tape recordings and an audiospectrograph. The purpose of this paper is to report on the variation in Carolina Wren songs as determined by audiospectrographic analyses of tape recordings.

This study has been aided by grants from the Development Fund and the Graduate School of Ohio State University. I am indebted to Dr. Carl R. Reese, of the Department of Zoology and Entomology, Ohio State University, for assistance in making many of the recordings, and to Mrs. Mary Jane Alluisi, of Ohio State University, for assistance in the preparation and analysis of the audiospectrographs. I wish to thank Dr. Carl R. Reese, Dr. Edward S. Thomas, and Mr. Jeff Swinebroad, of Ohio State University, for their careful reading and criticisms of the manuscript.

This study is based on 58 tape recordings of Carolina Wren songs made by my associates at Ohio State University and myself; 28 were made in Florida, 23 in Ohio, 4 in North Carolina, and 1 each in South Carolina, Alabama, and Kentucky. These recordings contain 71 song series and 753 songs; 18 of the Florida recordings, containing 24 song series, were made of a single individual in Myakka River State Park (this bird is hereinafter referred to as wren M-4). A list of the recordings studied is given in Table 1.

Five of the Ohio recordings (the first five listed in Table 1) were made with a Brush Soundmirror recorder, using a tape speed of 7.5 inches per second; all the others were made with a Magnemite recorder,

TABLE 1

CAROLINA WREN RECORDINGS STUDIED

Recording number	*Where recorded*	*Time of day*	*Date*	*Number of song series*	*Recorded by*
147	Eubank, Kentucky	6:30 A.M.	March 26, 1950	1	Borror
164	Worthington, Ohio	6:30 A.M.	May 3, 1950	4	Borror and Reese
172	Worthington, Ohio	6:05 A.M.	May 4, 1950	1	Borror and Reese
231	Columbus, Ohio	7:00 A.M.	April 19, 1951	1	Borror and Reese
232	Columbus, Ohio	7:15 A.M.	April 19, 1951	1	Borror and Reese
329	Delaware Co., Ohio	11:00 A.M.	March 14, 1953	1	Borror
355	Bradenton, Florida	10:30 A.M.	March 23, 1953	1	Borror
365	Columbus, Ohio	6:05 A.M.	April 3, 1953	1	Borror and Reese
371	Dublin, Ohio	9:30 A.M.	April 4, 1953	1	Richard Banks
428	Columbus, Ohio	6:30 A.M.	May 1, 1953	1	Borror
431	Columbus, Ohio	8:15 A.M.	April 29, 1953	1	Borror and Reese
438	Franklin Co., Ohio	6:00 A.M.	May 4, 1953	1	Borror and Reese
552	Columbus, Ohio	8:30 A.M.	May 28, 1953	1	Borror and Reese
663	Columbus, Ohio	9:25 A.M.	May 28, 1953	1	Borror and Reese
731	Columbus, Ohio	1:15 P.M.	March 6, 1954	1	Borror and Reese
737	Columbus, Ohio	8:50 A.M.	March 10, 1954	1	Borror and Reese
744	Gahanna, Ohio	9:30 A.M.	March 13, 1954	1	Borror
779	Columbus, Ohio	6:55 A.M.	March 27, 1954	3	Borror
802B	Troy, Alabama	7:55 A.M.	April 2, 1954	2	Borror
808B	Tallahassee, Florida	6:50 A.M.	April 3, 1954	1	Borror
825B	Myakka River State Park, Florida	7:30 A.M.	April 8, 1954	2	Borror (wren M-2)
828B	Myakka River State Park, Florida	6:00 P.M.	April 8, 1954	4*	Borror (wren M-4)
836B	Myakka River State Park, Florida	2:10 P.M.	April 9, 1954	1	Borror (wren M-4)
837B	Myakka River State Park, Florida	4:00 P.M.	April 9, 1954	1	Borror (wren M-4)
840B	Myakka River State Park, Florida	9:20 A.M.	April 10, 1954	1	Borror (wren M-4)
844B	Myakka River State Park, Florida	5:52 P.M.	April 10, 1954	1	Borror (wren M-4)
847B	Myakka River State Park, Florida	7:10 A.M.	April 11, 1954	1	Borror (wren M-3)
849B	Myakka River State Park, Florida	7:26 A.M.	April 11, 1954	1	Borror (wren M-2)
850B	Myakka River State Park, Florida	9:35 A.M.	April 11, 1954	2†	Borror (wren M-4)
853B	Myakka River State Park, Florida	2:35 P.M.	April 11, 1954	1	Borror (wren M-4)
854B	Myakka River State Park, Florida	3:22 P.M.	April 11, 1954	1	Borror (wren M-4)
855B	Myakka River State Park, Florida	3:47 P.M.	April 11, 1954	1	Borror (wren M-4)
858B	Myakka River State Park, Florida	6:15 A.M.	April 12, 1954	1	Borror (wren M-4)
859B	Myakka River State Park, Florida	6:25 A.M.	April 12, 1954	2	Borror (wren M-4)
862B	Myakka River State Park, Florida	7:12 A.M.	April 12, 1954	1	Borror (wren M-3)
863B	Myakka River State Park, Florida	9:25 A.M.	April 12, 1954	1	Borror (wren M-3)
866B	Myakka River State Park, Florida	9:55 A.M.	April 12, 1954	1	Borror (wren M-2)
868B	Myakka River State Park, Florida	10:14 A.M.	April 12, 1954	1	Borror (wren M-1)

TABLE 1 (Cont.)

Recording number	*Where recorded*	*Time of day*	*Date*	*Number of song series*	*Recorded by*
870B	Myakka River State Park, Florida	12:20 P.M.	April 12, 1954	1	Borror (wren M-4)
871B	Myakka River State Park, Florida	12:32 P.M.	April 12, 1954	1	Borror (wren M-4)
872B	Myakka River State Park, Florida	4:08 P.M.	April 12, 1954	2	Borror (wren M-4)
874B	Myakka River State Park, Florida	8:12 A.M.	April 13, 1954	1	Borror (wren M-4)
875B	Myakka River State Park, Florida	8:45 A.M.	April 13, 1954	1	Borror (wren M-4)
880B	Myakka River State Park, Florida	4:25 P.M.	April 13, 1954	1	Borror (wren M-4)
881B	Myakka River State Park, Florida	4:40 P.M.	April 13, 1954	1	Borror (wren M-4)
893B	Tampa, Florida	11:00 A.M.	April 17, 1954	1	Borror
910B	Ruffin, South Carolina	9:22 A.M.	April 23, 1954	1	Borror
915B	Greensboro, North Carolina	11:18 A.M.	April 24, 1954	1	Borror
918B	Greensboro, North Carolina	11:37 A.M.	April 24, 1954	1	Borror
922B	Greensboro, North Carolina	4:15 P.M.	April 24, 1954	1	Borror
932B	Greensboro, North Carolina	7:52 A.M.	April 25, 1954	1	Borror
951	Worthington, Ohio	8:03 A.M.	May 2, 1954	1	Borror
974	Franklin Co., Ohio	7:00 A.M.	May 8, 1954	1	Borror
1007	Westerville, Ohio	9:25 A.M.	May 13, 1954	1	Borror
1080	Brown Co., Ohio	6:58 P.M.	May 28, 1954	1	Borror
1084	Brown Co., Ohio	6:30 A.M.	May 29, 1954	1	Borror
1107	South Bloomingville, Ohio	4:56 P.M.	May 30, 1954	1	Borror and Reese
1131	Hocking Co., Ohio	8:13 A.M.	June, 6 1954	1	Borror

* For the first several songs in this recording the songs of two types alternate.
† The songs of the two types alternate in the recording.

using a tape speed of 15 inches per second. The recordings are in the Laboratory for the Study of Animal Sounds, Department of Zoology and Entomology, Ohio State University.

Samples of the 71 song series have been graphed with an audiospectrograph; this technique has been described in a previous paper (Borror and Reese, 1953). The audiospectrograph used in the preparation of these graphs was a Vibralyzer, manufactured by the Kay Electric Co., Pine Brook, N. J. Unless otherwise indicated, all graphs in this paper were made using the narrow band filter, and only a portion of each song is shown. All the graphs in a given plate, unless otherwise indicated, were made using the same time and frequency scales. The successive notes in the phrases of the Carolina Wren songs are indicated in the graphs by the letters A, B, C, etc.

SINGING BEHAVIOR

A Carolina Wren song consists of a series of similar phrases, each phrase consisting of two or more notes. The notes are uttered rapidly, and the entire song usually lasts two seconds or less. A given song

is usually sung at fairly regular intervals for a period of time (in this paper the term *song series* is used for such a group of similar songs), then the bird either stops singing for a while or starts singing a different song. In all but two of our 58 Carolina Wren recordings, successive songs are of the same type over a period of time; in two recordings (828B and 850B) the bird sang two song types alternately.

The rate of singing varies, both in a given song series and in the singing of different birds. A summary of the data on this point is given in Table 2; the time measurements were made to the nearest one-fourth second.

TABLE 2

SINGING RATE OF CAROLINA WRENS

Source of recordings		*Number of measurable intervals between songs*	*Time in seconds from beginning of one song to beginning of next*	
			Range	*Mean* $\pm \sigma_m$
Florida	M-4	147	4.50–12.50	6.06 ± 0.12
	Others	72	3.25–14.00	6.98 ± 0.25
	Total	219	3.25–14.00	6.37 ± 0.12
Ohio		335	2.50– 8.50	4.41 ± 0.02
Miscellaneous		57	4.00–12.25	5.88 ± 0.21
All recordings		611	2.50–14.00	5.25 ± 0.07

There is no indication in my data of any factors which might influence or be correlated with the singing; there is no correlation, for example, between the singing rate and the time of day the bird was singing. There was greater variation in singing rate in some song series than in others, even with the same bird. In many of the longer recordings, containing a dozen or more songs, some intervals between songs were twice as long as other intervals. The greatest variation in a single recording was in No. 164, which is the longest recording (nearly 14 minutes); this recording contains four song series, of 11, 53, 89, and 51 songs. The time from the beginning of one song to the beginning of the next averaged 4.36 sec. in the first series, 4.20 sec. in the second, 3.39 sec. in the third, and 3.61 sec. in the fourth. The bird was apparently not becoming tired.

The singing rate in the birds recorded varied from 4.3 to 24.0 songs per minute, and from 4.8 to 13.3 per minute in the songs of one individual. The singing rate averaged 11.4 songs per minute in all the recordings and was significantly higher in Ohio birds than in Florida birds.

SONG LENGTH

The measurements of song length were made to the nearest 0.01 sec. on graphs made using the wide band filter. These measurements are summarized in Table 3.

TABLE 3

SUMMARY OF DATA ON THE LENGTH OF CAROLINA WREN SONGS

Source of recordings		*Number of series*	*Number of songs*	*Range*	*Song length (in seconds) Mean ± σ_m Based on all songs*	*Based on series averages*
Florida	M-4	24	174	0.93–2.43	1.80 ± 0.02	1.76 ± 0.04
	Others	11	88	0.85–2.37	1.68 ± 0.03	1.72 ± 0.08
	Total	35	262	0.85–2.43	1.76 ± 0.02	1.75 ± 0.04
Ohio		28	413	0.51–2.42	1.46 ± 0.01	1.51 ± 0.05
Miscellaneous		8	78	1.11–2.24	1.73 ± 0.03	1.78 ± 0.08
All recordings		71	753	0.51–2.43	1.60 ± 0.01	1.66 ± 0.03

In any given series of songs, the songs containing the same number of phrases did not vary more than 0.01 or 0.02 sec. in length, but there was considerable variation in the lengths of songs of different types, and (in a given series) of songs containing different numbers of phrases. In several song series there were some songs twice as long as others, and in one Ohio series (164-III, with 89 songs) some songs were more than three times as long as others.

The recorded songs varied in length from 0.51 to 2.43 sec. and averaged 1.60 sec. Because different series contained different numbers of songs, an average based on the series averages may more nearly represent the average for the species; this average was 1.66 sec. The songs of Ohio birds averaged significantly shorter than those of Florida birds.

THE PHRASES OF CAROLINA WREN SONGS

The phrases of Carolina Wren songs vary in completeness, number, length, the number of notes they contain, and in the character of the notes. Some of these variations (e.g., in phrase number and completeness) occur in the songs of a given series; other variations occur in the different songs of a given bird and in the songs of different birds.

Phrase Completeness.—All the phrases in a song may be complete (Plate 3, Figure 1), or the first and/or last phrase of the song may be incomplete (Figures 2–4), that is, the bird may begin and/or end a song in the middle of a phrase. The first note or two of the song may in some cases be quite weak compared with these same notes in subsequent phrases (Figure 4). The songs of one Ohio bird began with a note that was different from any others in the song (Plate 4, Figure 5, A).

When all the phrases of a song are not complete, it is sometimes difficult to determine whether it is the first or the last phrase that is incomplete. The phrases of some songs are fairly distinct, with a

longer interval between phrases than between any two notes in a phrase; in other songs (e.g., Plate 3, Figure 3) the notes are more evenly spaced and the phrases are less distinct. The limits of the phrases were determined by listening to the recordings played at a reduced tape speed.

TABLE 4

COMPLETENESS OF PHRASES IN CAROLINA WREN SONGS

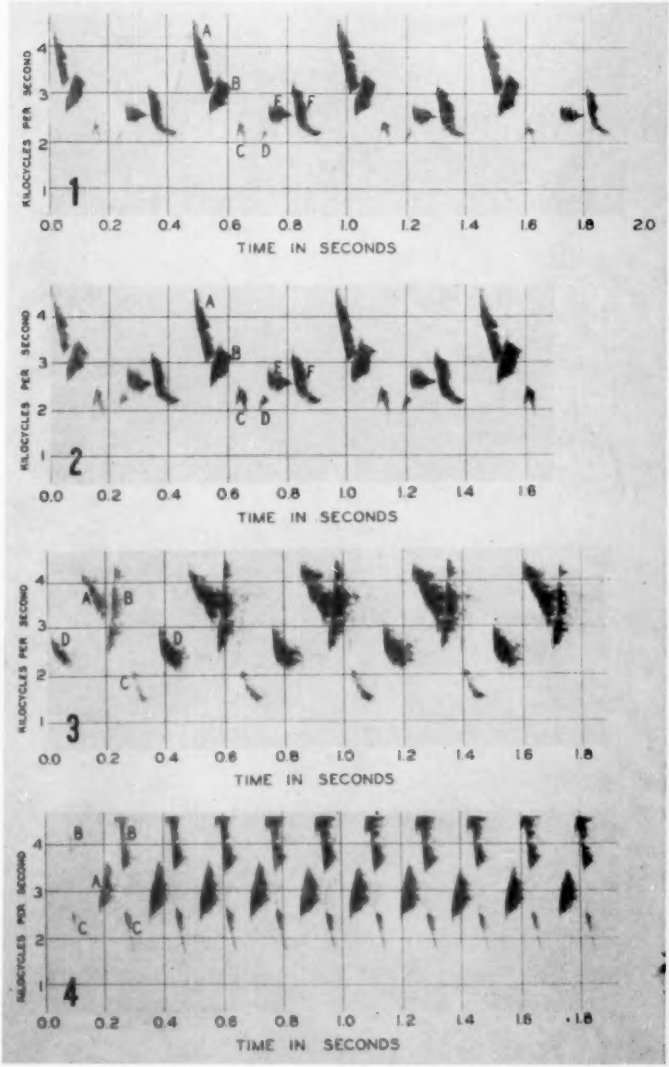
Completeness of phrases	*Florida*			*Ohio*	*Misc.*	*Total*
	M-4	*Others*	*Total*			
All phrases complete	17.72*	9.68	27.40	12.58	3.20	43.18
	73.83†	88.00	78.29	44.93	40.00	60.82
Last phrase incomplete	4.18	0.25	4.43	13.42	4.80	22.65
	17.42	2.27	12.66	47.93	60.00	31.90
First phrase incomplete	1.10	0.00	1.10	1.00	0.00	2.10
	4.58	0.00	3.14	3.57	0.00	2.96
First and last phrases incomplete	1.00	1.07	2.07	1.00	0.00	3.07
	4.17	9.73	5.91	3.57	0.00	4.32
Total song series	24	11	35	28	8	71

* The upper figure of each pair is the number of song series which have the phase completeness indicated; fractions take into account variations within a single song series.

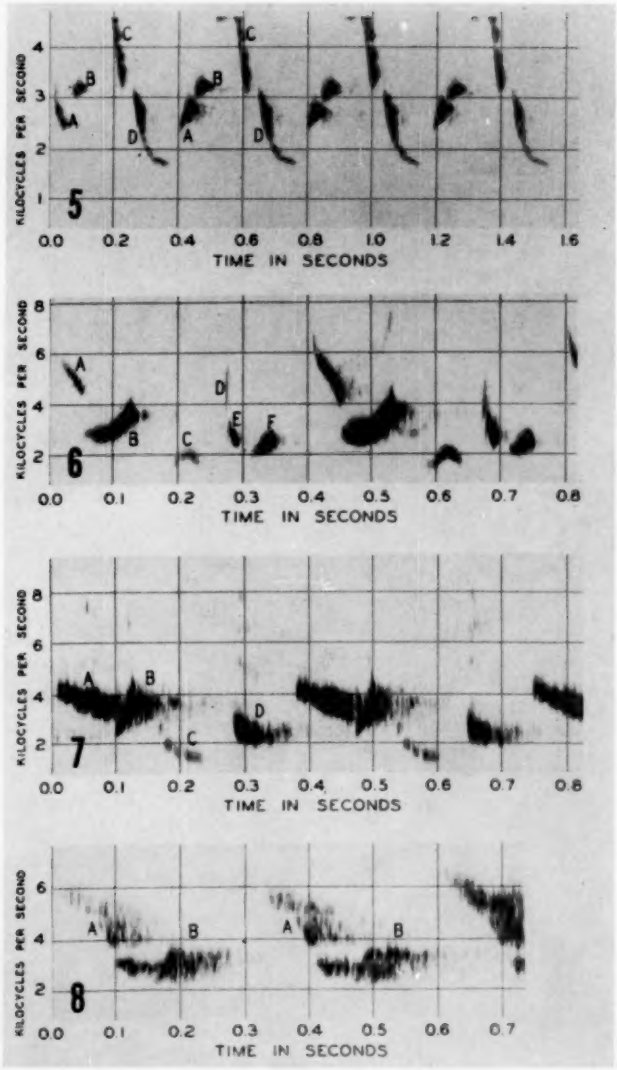
† The lower figure of each pair is the percentage of the song series from the locality in question.

The data on phrase completeness in the songs in our recordings are summarized in Table 4. All the phrases were complete in most (60.82 per cent) of the song series; nearly a third (31.90 per cent) had all but the last phrase of the song complete; only a few had the first phrase (2.96 per cent) or both the first and last phrases (4.32 per cent) incomplete. The last phrase of the song was incomplete considerably more often in the songs of northern birds than in those of Florida birds. All the songs in a series were alike in phrase completeness in about four series out of five (81.69 per cent), and this percentage varied but little in the series from different areas. In about ten per cent of the songs the first note of the first phrase was considerably weaker than in subsequent phrases (e.g., Plate 4, Figure 6, A). The variation in phrase completeness was about the same in the songs of a given individual (e.g., wren M-4) as in all the recorded songs of the species.

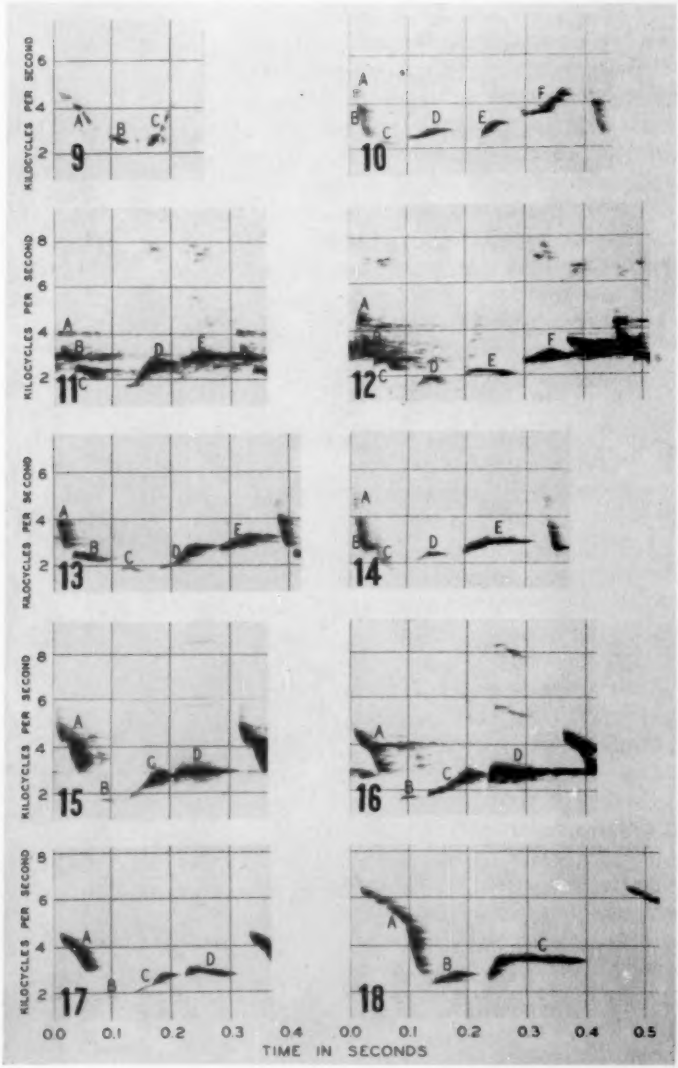
The Number of Phrases in a Song.—The data on the number of phrases in the Carolina Wren songs in our recordings are summarized in Table 5. For the purpose of this table, each incomplete phrase was counted as a phrase, except in cases where both the first and last phrases of the song were incomplete; since these two incomplete phrases were always less than a single complete phrase they were counted in the table as one phrase.



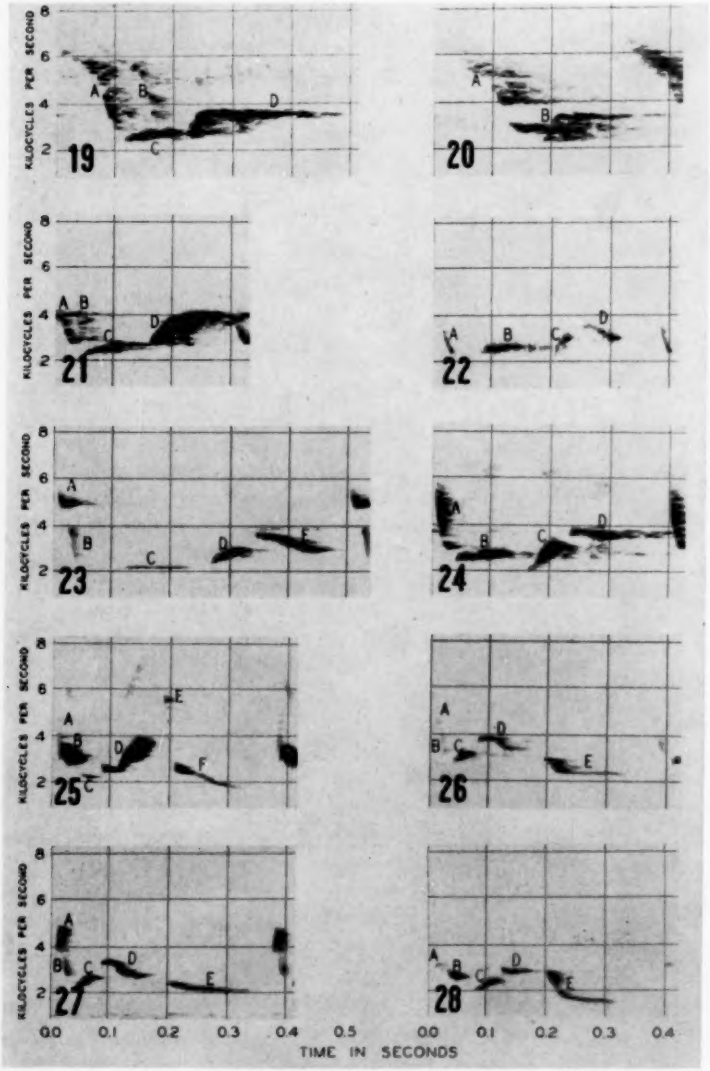
AUDIOSPECTROGRAPHS OF CAROLINA WREN SONGS; each graph shows the entire song. Figures 1 and 2, two songs from series 779-I; the first contains four complete phrases, and the second contains three complete phrases and a partial fourth phrase. Figure 3, a song from series 855B, with both the first and the last phrases incomplete. Figure 4, a song from series 866B, with the first phrase incomplete; the frequencies in note B extend slightly beyond the limit of the graph (cf. Plate 10, Figure 68).



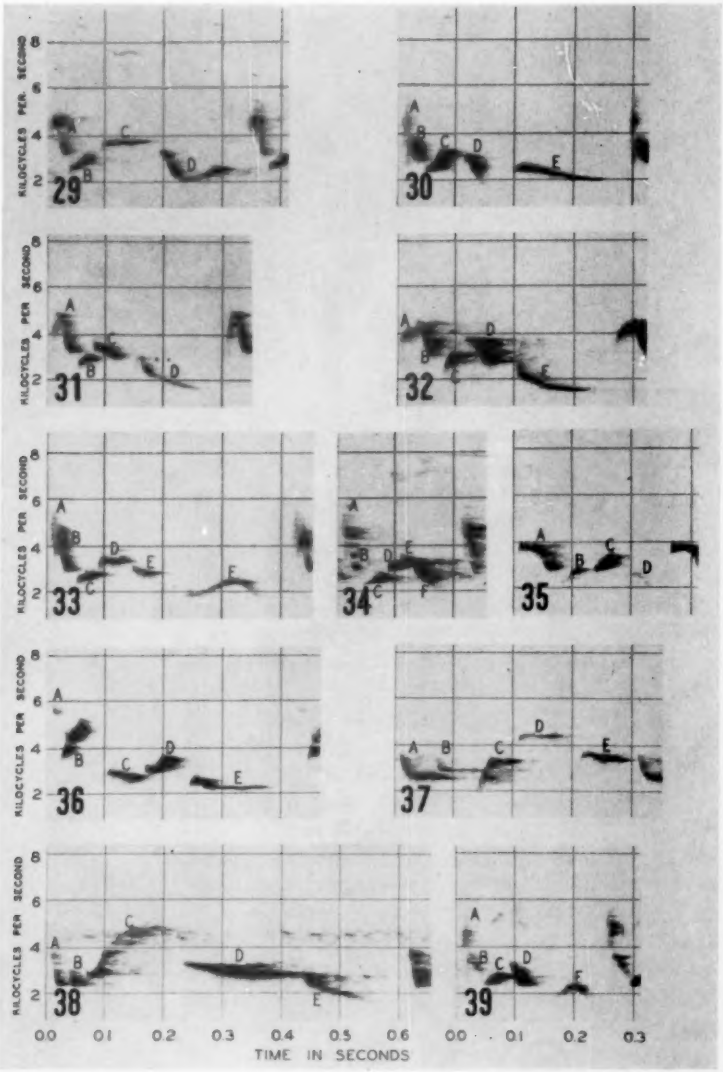
AUDIOSPECTROGRAPHS OF CAROLINA WREN SONGS; FIGURE 5 made using the narrow-band filter, and Figures 6-8 with the wide-band filter. Figure 5, a song from series 951; note A in the first phrase is different from the A note in the other phrases; the frequencies in note C extend slightly beyond the limit of the graph (cf. Figure 71). Figure 6, the first two phrases of a song in series 871B, a song showing very little modulation (cf. Figure 52). Figure 7, two phrases of a song in series 855B, a song showing some modulation (cf. Figures 3 and 75). Figure 8, two phrases of a song in series 828B-IV, a song showing considerable modulation (cf. Figure 20).



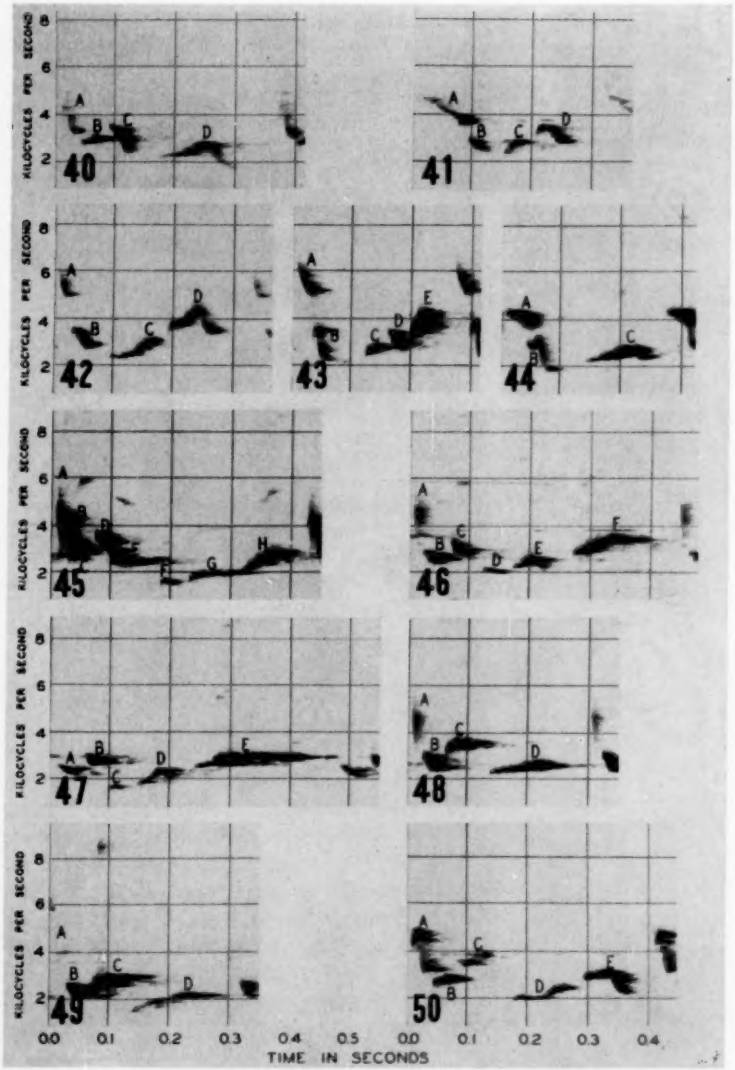
AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 9, series 232. Figure 10, series 910B. Figure 11, series 428. Figure 12, series 1107. Figure 13, series 552. Figure 14, series 932B. Figure 15, series 862B. Figure 16, series 863B. Figure 17, series 825B-I. Figure 18, series 874B.



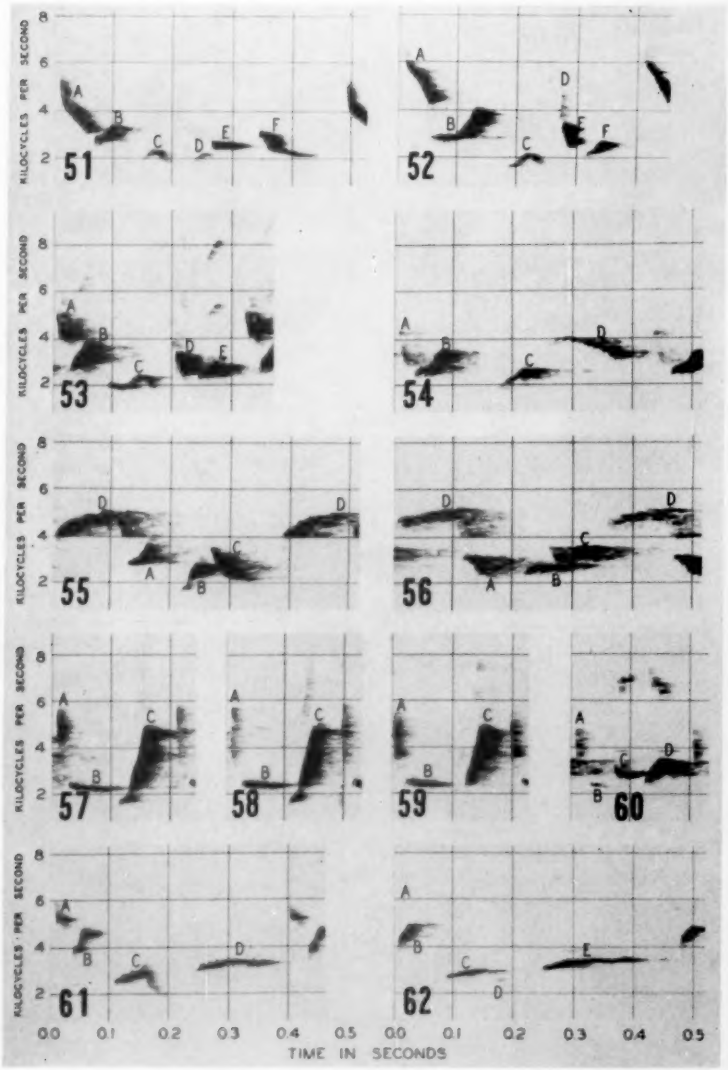
AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 19, series 859B-II. Figure 20, series 828B-IV. Figure 21, series 853B. Figure 22, series 147. Figure 23, series 779-III. Figure 24, series 918B. Figure 25, series 825B-II. Figure 26, series 172. Figure 27, series 438. Figure 28, series 1080.



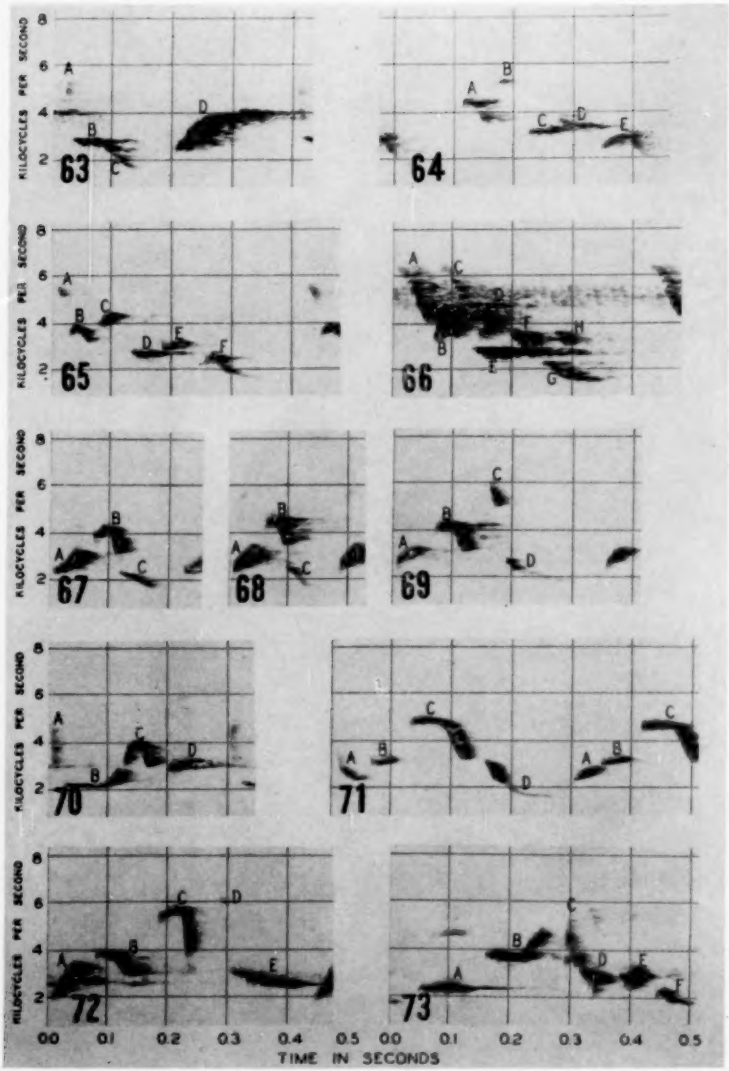
AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 29, series 329. Figure 30, series 802B-I. Figure 31, series 808B. Figure 32, series 854B. Figure 33, series 779-II. Figure 34, series 881B. Figure 35, series 849B. Figure 36, series 1131. Figure 37, series 164-II. Figure 38, series 1084; the noise in the background (between about 4000 and 5000 cps) is that of an insect. Figure 39, series 663.



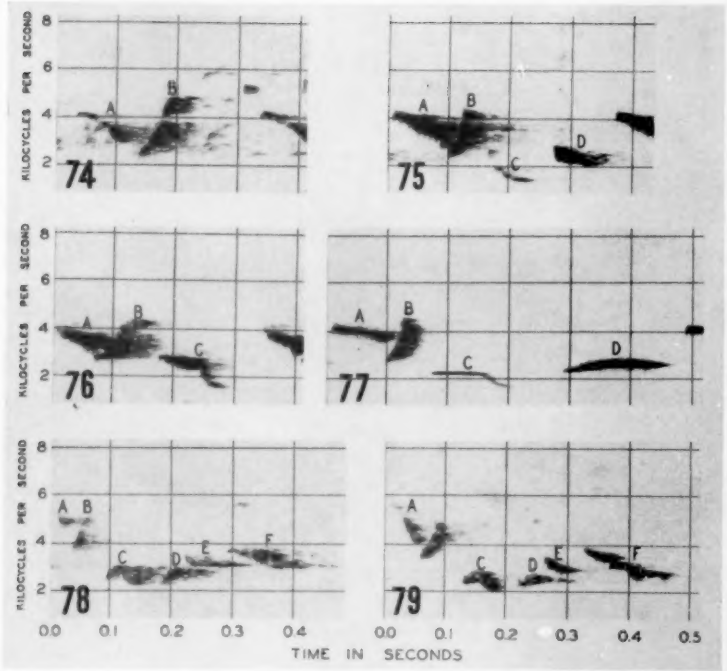
AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 40, series 731. Figure 41, series 893B. Figure 42, series 802B-II. Figure 43, series 828B-III. Figure 44, series 1007. Figure 45, series 872B-I. Figure 46, series 868B. Figure 47, series 828B-I. Figure 48, series 875B. Figure 49, series 828B-II. Figure 50, series 922B.



AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 51, series 779-I. Figure 52, series 871B. Figure 53, series 872B-II. Figure 54, series 164-III. Figure 55, series 858B. Figure 56, series 837B. Figure 57, series 870B. Figure 58, series 850B-I. Figure 59, series 840B. Figure 60, series 880B. Figure 61, series 974. Figure 62, series 737.



AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS. Figure 63, series 836B. Figure 64, series 164-IV. Figure 65, series 431. Figure 66, series 859B-I; the noise in the background (between about 4700 and 5700 cps) is that of an insect. Figure 67, series 844B. Figure 68, series 866B. Figure 69, series 915B. Figure 70, series 850B-II. Figure 71, series 951 (cf. Figure 5). Figure 72, series 365. Figure 73, series 231.



AUDIOSPECTROGRAPHS OF INDIVIDUAL PHRASES OF CAROLINA WREN SONGS Figure 74, series 744. Figure 75, series 855B. Figure 76, series 355. Figure 77 series 847B. Figure 78, series 164-I. Figure 79, series 371.

TABLE 5

SUMMARY OF DATA ON THE NUMBER OF PHRASES IN CAROLINA WREN SONGS

		Number of Songs					
Number of phrases in song		*M-4*	*Others Florida*	*Total Florida*	*Ohio*	*Other states*	*Total—all states*
2		0	4	4	4	0	8
3		2	11	13	85	0	98
4		18	19	37	234	11	282
5		47	17	64	80	39	183
6		50	13	63	9	22	94
7		4	19	23	1	6	30
8		9	1	10	0	0	10
9		27	0	27	0	0	27
10		17	0	17	0	0	17
11		0	3	3	0	0	3
12		0	1	1	0	0	1
Total		174	88	262	413	78	753
Number of song series		24	11	35	28	8	71
Number of phrases in song	*Range*	3 to 10	2 to 12	2 to 12	2 to 7	4 to 7	2 to 12
	Average Based on all songs	6.47 ±0.15	5.30 ±0.21	6.08 ±0.13	4.02 ±0.04	5.29 ±0.09	4.87 ±0.06
	Average Based on series Average	6.08 ±0.39	5.71 ±0.69	5.96 ±0.34	4.21 ±0.15	5.31 ±0.27	5.20 ±0.20
Coefficient of correlation between number of phrases in song and phrase length	*Based on all songs*	−0.913*	−0.833*	−0.886*	−0.398*	−0.647*	−0.799*
	Based on average number of phrases in each song series	−0.942*	−0.856*	−0.910*	−0.539*	−0.618†	−0.826*

* Highly significant. † Scarcely significant.

The phrases in different songs varied in number from 2 to 12, and from 3 to 10 in the different songs of one bird (wren M-4). The songs in a given series usually did not vary more than a phrase or two in length. The songs of Florida birds contained, on the average, significantly more phrases than the songs of Ohio birds. The songs in our recordings averaged 4.87 phrases per song (based on series averages, the average was 5.20 phrases per song).

The Length of a Phrase.—The data on phrase length are summarized in Table 6. The phrase length varied from 0.169 to 0.620 sec. in all the songs studied, and from 0.195 to 0.460 sec. in the different songs of one bird (wren M-4). There was a significant correlation between the phrase length and the number of phrases in the song (except in the miscellaneous songs, in which correlation was based on the average number of phrases per song in each song series); in general, the more phrases in the song, the shorter these phrases were (Table 5). The phrases in the songs of Florida birds averaged

TABLE 6

SUMMARY OF DATA ON PHRASE LENGTH AND THE NUMBER OF NOTES PER PHRASE IN CAROLINA WREN SONGS

		Source of recordings					
		M-4	*Others Florida*	*Total Florida*	*Ohio*	*Other states*	*Total—all states*
Number of song series		*24*	*11*	*35*	*28*	*8*	*71*
Phrase length	*Range*	0.195 to 0.460	0.169 to 0.582	0.169 to 0.582	0.247 to 0.620	0.316 to 0.400	0.169 to 0.620
	Average	0.322 ±0.018	0.345 ±0.032	0.329 ±0.016	0.401 ±0.015	0.375 ±0.010	0.363 ±0.010
Notes per phrase	*Range*	2 to 8	3 to 6	2 to 8	2 to 6	4 to 6	2 to 8
	Average	4.42 ±0.30	4.18 ±0.30	4.34 ±0.22	4.86 ±0.20	4.63 ±0.26	4.58 ±0.14
Coefficient of correlation between phrase length and the number of notes per phrase		0.381‡	0.379‡	0.356†	0.509†	0.497‡	0.448*

* Highly significant. † Significant. ‡ Not significant.

significantly shorter than those in the songs of Ohio birds. There was a significant correlation between the length of a phrase and the number of notes it contained, considering all the songs studied; in some series this correlation was not significant (Table 6).

The Number of Notes per Phrase.—It is relatively easy to determine the number of notes per phrase in some songs, but in others this is not the case. The notes in many songs are more or less run together and considerably modulated, so that it is difficult to determine where one note ends and the next begins. In some songs, two or three distinct frequency bands may be uttered at the same time; when these are separated and are not harmonics, they are considered as distinct notes. A bird may sometimes utter a note containing a given band of frequencies, and before ending that note begin another containing a different band of frequencies; in other songs the bird may maintain a note of a given frequency for a short period, and at the same time utter another that is slurred downward in frequency. A single note slurred over a considerable frequency range in one phrase may in another phrase of the same song be divided into two notes slurring over this same frequency range; in such cases this is counted as one note, if it appears as such in any phrase of the song.

I have in general counted as a single note what shows as a single "blob" on a graph made using the narrow band filter; cases where only the wide band graph shows that an up-slur and a down-slur are connected are considered as single notes (e.g., Plate 8, Figure 42, D).

Table 6 contains a summary of the number of notes per phrase in the Carolina Wren songs in our recordings. The phrases contained from 2 to 8 notes each, averaging 4.58 notes. The differences in the number of notes per phrase in the songs from different areas were scarcely significant.

TYPES OF NOTES IN CAROLINA WREN SONGS

The individual notes in Carolina Wren songs vary in length, loudness, and degree of modulation, and they may be either steady in pitch or slurred. Occasionally a bird will utter complex notes: two or three distinct groups of frequencies uttered simultaneously. The notes are generally short (rarely over 0.10 sec. in length), loud, and separated by intervals that are seldom longer than the notes themselves.

The notes of this species can be grouped into three categories: (1) notes that are little or not at all slurred, (2) slurred notes, and (3) notes containing both steady and slurred elements.

The notes that are little or not at all slurred are of two types, (a) musical notes, containing a fairly narrow band of frequencies, and (b) noise-like notes, containing a relatively broad band of frequencies. Notes of the first type are usually at least 0.05 sec. in length, and may be 0.10 sec. or more in length (e.g., Plate 6, Figures 23, C, and Plate 7, Figure 37, D); they sometimes are slurred upward (e.g., Plate 9, Figure 61, D) or downward (e.g., Plate 11, Figure 78, E) very slightly at the beginning. Notes of the second type (e.g., Plate 9, Figure 60, A) are always very short and weak. About 12 per cent of all the notes in our recordings were of the first type, and about 5 per cent were of the second type; notes of the second type were more frequent in the songs of Florida birds than in the songs of Ohio birds.

Slurred notes may be slurred upward or downward, or may contain both up- and down-slurred elements. The slurring may occur very quickly (e.g., Plate 6, Figure 24, A, and Plate 9, Figure 59, C) or over a longer period (e.g., Plate 7, Figure 30, E, and Plate 10, Figure 63, D), and may be at a uniform rate (represented graphically by a slanting straight band) or at a variable rate (represented graphically by a slanting curved band, e.g., Plate 5, Figure 18, A, and Plate 7, Figures 31, D, and 38, C). The slurring may be over a varying frequency range, up to an octave or more (Plate 5, Figure 18, A). Down-slurred notes occur a little more frequently than up-slurred notes; these two types made up about 64 per cent of all the notes in our recordings, and the percentage varied little in the songs of birds from different localities.

Notes that are first slurred upward and then downward made up about 12 per cent of all the notes, and occurred more frequently in the songs of Ohio birds than in the songs of Florida birds. These notes vary somewhat, particularly in the extent of the up-slurring at the beginning of the note; in most cases the up-slurred part of the note is short and the slurring is over a short frequency range (e.g., Plate 8, Figure 43, B), with the down-slurred part longer and over a greater frequency range. Notes of this type look a little like a crochet hook when graphed and are often preceded by a weak, very short, rapidly up-slurred note (e.g., Plate 7, Figures 30 and 33, notes A and B). In other cases the up-slurred part of the note is longer, and the note graphically resembles an inverted "V" (e.g., Plate 8, Figure 42, D, and Plate 10, Figure 70, C).

Notes that are first down-slurred and then up-slurred occur but are scarce, making up less than two per cent of all the notes (e.g., Plate 7, Figure 29, D).

Notes containing both steady and slurred elements are uncommon, making up only about five per cent of all the notes, and are of four main types: (a) steady, then up-slurred (e.g., Plate 9, Figure 52, B), (b) steady, then down-slurred (e.g., Plate 10, Figure 71, C), (c) up-slurred, then steady (e.g., Plate 5, Figure 18, C), and (d) down-slurred, then steady (e.g., Plate 6, Figure 26, E). The steady portion of these notes is usually at least 0.05 sec. in length.

Most of the notes in our Carolina Wren songs (83 per cent) were slurred or contained portions that were slurred. Relatively few notes (17 per cent) were steady in pitch. The songs of the northern birds contained a higher proportion of slurred notes than the songs of Florida birds. About one-fifth of the notes in our recordings contained either both up- and down-slurred elements or both steady and slurred elements. The proportion of such notes was higher in the songs of Ohio birds than in the songs of Florida birds.

Some Carolina Wren songs show a high degree of modulation, while others show relatively little. (A note is said to be modulated when it consists of a very rapid series of short pulses, rather than a steady output of sound.) Of the 71 song series in our recordings, 38 showed very little modulation (e.g., Plate 4, Figure 6), 20 show some modulation (e.g., Figure 7), and 13 showed considerable modulation (e.g., Figure 8); this proportion was about the same in the songs of birds from different localities.

Complex notes in which two or more notes or distinct frequency bands are uttered simultaneously occurred in about one-fifth (21.1 per cent) of the songs; they occurred somewhat more often in the songs

of wren M-4 at Myakka River State Park, Florida (24.1 per cent) than in the songs of Ohio birds (17.9 per cent).

Most cases of complex notes in these songs were the result of one note continuing for a short time after the following note began; in a few cases a single note (at least with the frequency bands connected) contained both steady and slurred elements (e.g., Plate 10, Figure 65, F); in one case (series 859B-I) three notes were uttered simultaneously. Where one note began before the previous note ended, one of the notes (usually the first) was generally steady in pitch while the other was slurred (e.g., Plate 10, Figure 63, B and C); rarely (Plate 5, Figure 12, B and C) a note that slurred upward and then downward was uttered before a preceding note ended. In a few cases (e.g., Plate 8, Figure 43, D and E, and Plate 9, Figures 55–56, D and A) one slurred note followed another before the first one ended. At one point in each phrase of 859B-I (Plate 10, Figure 66) there was a moment when two down-slurred notes (H and G) and a steady note (E) were uttered simultaneously.

FREQUENCIES IN CAROLINA WREN SONGS

The frequencies in the Carolina Wren songs recorded were measured on graphs made using the narrow band filter. These measurements are believed to be accurate to within about two per cent of the frequency range covered by the graph; the possible error in the lower frequencies of the songs is about one musical interval (one half-note on the piano), and less in the higher frequencies of the song. The error may be greater in the case of weak notes.

Table 7 summarizes the data on the range in pitch in the Carolina Wren songs studied. The octave of the approximate piano note equivalent is indicated in this table by a subscript number; middle C on the piano (256 cps) would be represented by C_0, the C above middle C (512 cps) by C_1, etc.; thus the notes in the second octave above middle C would be those from C_2 (1024 cps) through B_2 (1920 cps). The highest note on the piano is C_4 (4096 cps). One musical interval is one half-note on the piano; 12 intervals make an octave.

The range in pitch in the various songs of a single individual (wren M-4, Table 7) was as great as that in the songs of different individuals. The notes in the different songs of a single individual varied in pitch over more than two octaves (1300–7000 cps, 29 intervals), even in a given song (25 intervals in series 871B, the song with the greatest pitch range). The lowest pitch in different songs varied over nearly an octave (11 intervals), and the highest pitch varied over slightly more than an octave (13 intervals).

TABLE 7

PITCH RANGE IN CAROLINA WREN SONGS

			Source of recordings					
			M-4	*Others Florida*	*Total Florida*	*Ohio*	*Other states*	*Total—all states*
Lowest pitch in song	*Range*	*cps*	1300 to 2400	1500 to 2300	1300 to 2400	1500 to 2300	1700 to 2400	1300 to 2400
		Approximate piano note	E_2 to D $\sharp_3$	G_2 to D_3	E_2 to D $\sharp_3$	G_2 to D_3	A_2 to D $\sharp_3$	E_2 to D $\sharp_3$
	Average	*cps*	1821 ±77	1800 ±73	1814 ±57	1907 ±45	2025 ±90	1875 ±35
		Approximate piano note	A $\sharp_2$	A $\sharp_2$	A $\sharp_2$	B_2	C_3	B_2
Highest pitch in song	*Range*	*cps*	3200 to 7000	4000 to 5700	3200 to 7000	3200 to 6100	4200 to 6100	3200 to 7000
		Approximate piano note	G $\sharp_3$ to A_4	C_4 to F $\sharp_4$	G $\sharp_3$ to A_4	G $\sharp_3$ to G_4	C $\sharp_4$ to G_4	G $\sharp_3$ to A_4
	Average	*cps*	5404 ±194	4927 ±162	5254 ±146	5096 ±134	5288 ±219	5196 ±92
		Approximate piano note	F_4	D $\sharp_4$	E_4	E_4	E_4	E_4
Pitch range in individual songs (in musical intervals)		*Range*	13 to 25	11 to 22	11 to 25	12 to 23	10 to 20	10 to 25
		Average	18.88 ±0.79	16.82 ±0.92	18.23 ±0.63	16.96 ±0.52	16.50 ±1.04	17.54 ±0.39

There was not much difference in the frequencies present in the songs of birds from different localities. Both the lowest (1300 cps) and the highest (7000 cps) frequencies found in any song were found in the songs of a Florida bird (wren M-4). The differences in pitch range in the songs of birds from different localities were not significant.

SONG PATTERNS (PHONETICS) IN CAROLINA WREN SONGS

Bird songs are often described in terms of their rhythms or patterns by the use of words or syllables that sound like the song. A great many such descriptive words have been applied to the songs of the Carolina Wren, e.g., *tea-kettle, tea-kettle, tea-kettle; jew-Peter, jew-Peter, jew-Peter;* and *che-wortel, che-wortel, che-wortel.* Such paraphrasing of a song is useful in describing its phonetics or pattern but is often of little value in critical diagnosis. Two or more people listening to the same song might paraphrase it differently, or a person might paraphrase two different songs similarly.

The audiospectrograph is of great value in demonstrating the pattern of any given song, and in showing slight differences in similar songs. Sample phrases from each of the 71 song series studied are shown

in Plates 5–11 (Figures 9–79). The graphs show that there is a tremendous variety in the patterns of different Carolina Wren songs.

Classification of Carolina Wren Song Patterns.—The principal basis of the classification here proposed is the pitch trend of the notes in an individual phrase of the song. The chief difficulty encountered in applying such a criterion was the delimiting of the phrases; when there was any doubt from an examination of the graph, the phrases were delimited by listening to the recording played at a reduced tape speed. A different delimitation of the phrases would for most songs result in a different classification.

On this basis our Carolina Wren songs may be classified into four groups, the largest of which may be further subdivided. This classification is outlined below.

I. Songs with the pitch falling at the beginning of a phrase and rising in the notes later in the phrase (Plates 5–10, Figures 9–63).
   A. The pitch in a phrase first falling, then rising, without marked irregularities (Plates 5–6, Figures 9–25).
   B. The pitch rising and then falling, following the first (down-slurred) note of the phrase; the last note of the phrase usually long and down-slurred (Plates 6–7, Figures 26–38).
   C. Two groups of notes that rise and fall in pitch, following the first (down-slurred) note of the phrase (Plates 7–8, Figures 39–40).
   D. The down-slurring at the beginning of the phrase consisting of two notes, with irregularities in the general pitch trend in the rest of the phrase (Plate 8, Figures 41–49).
   E. The phrase beginning with two strong notes, the first down-slurred and the second up-slurred, the first note higher in pitch than the second; the pitch in the rest of the phrase fluctuating (Plates 8–9, Figures 50–56).
   F. The phrases short and containing only two notes that are strong, a low steady note and a rapidly up-slurred note (Plate 9, Figures 57–60).
   G. The phrases consisting of two or three notes of decreasing pitch and ending in a relatively long note that may be up-slurred at the beginning (Plates 9–10, Figures 61–63).

II. Songs in which the general trend in pitch through the phrase is downward (Plate 10, Figures 64–66).

III. Songs in which the pitch rises at the beginning of the phrase and falls later in the phrase (Plate 10, Figures 67–73).

IV. Songs in which the phrases begin with a down-slurred note followed by an up-slurred note, these two notes covering a similar range in pitch (Plate 11, Figures 74–79).

TABLE 8

CLASSIFICATION OF CAROLINA WREN SONGS

Series	*Classification*	*Figure*	*Series*	*Classification*	*Figure*	*Series*	*Classification*	*Figure*
Wren M-4, Florida			*Other Florida Birds*			*Ohio birds–cont.*		
828B-I	I-D	47	355	IV	76	552	I-A	13
828B-II	I-D	49	808B	I-B	31	663	I-C	39
828B-III	I-D	43	825B-I	I-A	17	731	I-C	40
828B-IV	I-A	20	825B-II	I-A	25	737	I-G	62
836B	I-G	63	847B	IV	77	744	IV	74
837B	I-E	56	849B	I-B	35	779-I	I-E	51
840B	I-F	59	862B	I-A	15	779-II	I-B	33
844B	III	67	863B	I-A	16	779-III	I-A	23
850B-I	I-F	58	866B	III	68	951	III	71
850B-II	III	70	868B	I-D	46	974	I-G	61
853B	I-A	21	893B	I-D	41	1007	I-D	44
854B	I-B	32	*Ohio birds*			1080	I-B	28
855B	IV	75				1084	I-B	38
858B	I-E	55	164-I	IV	78	1107	I-A	12
859B-I	II	66	164-II	I-B	37	1131	I-B	36
859B-II	I-A	19	164-III	I-E	54			
870B	I-F	57	164-IV	II	64	*Miscellaneous birds*		
871B	I-E	52	172	I-B	26			
872B-I	I-D	45	231	III	73	147	I-A	22
872B-II	I-E	53	232	I-A	9	802B-I	I-B	30
874B	I-A	18	329	I-B	29	802B-II	I-D	42
875B	I-D	48	365	III	72	910B	I-A	10
880B	I-F	60	371	IV	79	915B	III	69
881B	I-B	34	428	I-A	11	918B	I-A	24
			431	II	65	922B	I-E	50
			438	I-B	27	932B	I-A	14

An attempt has been made to number the figures so that the closer together the figures of any two series are (within a given group of the classification) the more alike the songs are. The classification and figure number of each song series are given in Table 8.

A summary of the number of song patterns in each group from the different localities is given in Table 9. All of the major groups were represented in both the Florida and Ohio songs, and most of these groups were about equally well represented in the songs from these two areas. The patterns of subgroups B and D, group I, were more common in Ohio songs than in Florida songs, and the patterns of subgroup F, group I, occurred only in Florida songs. Thus there appears to be only a little geographic variation in the song patterns of this species.

Cases of Identical Patterns Sung by Different Birds.—The songs listed in a given group in the above classification are similar, but not necessarily identical. Two or more song patterns may appear identical or nearly so to the ear, but the ear frequently does not detect the minor differences that are brought out by the audiospectro-

TABLE 9

OCCURRENCE OF DIFFERENT PATTERNS OF CAROLINA WREN SONGS IN RECORDINGS MADE IN DIFFERENT LOCALITIES

Song pattern group		*Number of song series*					
		M-4	*Others Florida*	*Total Florida*	*Ohio*	*Other states*	*Total—all states*
Group I	A	4	4	8	5	4	17
	B	2	2	4	8	1	13
	C	0	0	0	2	0	2
	D	5	2	7	1	1	9
	E	4	0	4	2	1	7
	F	4	0	4	0	0	4
	G	1	0	1	2	0	3
	Total	20	8	28	20	7	55
Group II		1	0	1	2	0	3
Group III		2	1	3	3	1	7
Group IV		1	2	3	3	0	6
Total		24	11	35	28	8	71

graph. The best method of determining just how similar any two songs are is to compare their audiospectrographs.

There are several cases of striking similarity in the songs of different series:

1. The series represented by Plate 5, Figures 15 (862B), 16 (863B), and 17 (825B-I), recorded in Myakka River State Park, Florida. The patterns of these three series are practically identical; that of Figure 17 is perhaps a little different from that of the other two (the last note of the phrase is a little less strong). Recordings 862B and 863B were made about 75 yards and two and one quarter hours apart, and were thought to be made by the same bird; 825B was recorded about one-fourth mile from the points where the other two recordings were made. The differences in the three graphs are probably no greater than might be encountered in graphs of different songs in the same series. It would thus appear that two different birds in Myakka River State Park were singing the same song.

2. The series represented by Plate 6, Figures 22 (147, Ky.) and 23 (779-III, Ohio). Recording 147 is a very poor one and the graph of it is not clear, but from what can be made out for 147 it appears that these two are the same pattern.

3. The series represented by Plate 9, Figures 57–59 (870B, 850B-I, and 840B) are recordings of the same bird, wren M-4 in Myakka River State Park, Florida. These are identical, indicating that the bird sang this particular pattern on at least three different occasions. The pattern in Figure 60 (880B), sung by the same bird, is very similar, but it is not quite identical.

4. The series represented by Plate 10, Figures 67 (844B, wren M-4, Florida), 68 (866B, wren M-1, Florida), and 69 (915B, N. C.). Recordings 844B and 866B were made about one-half mile apart. The patterns in Figures 67 and 68 are identical except for the phrase length; the latter has shorter phrases than the former. The pattern in Figure 69 is extremely similar but has an extra note in the phrase (note C), and the phrases are still longer than in the other two patterns.

5. The series represented by Plate 11, Figures 78 (164-I, Worthington, Ohio) and 79 (371, Dublin, Ohio). These two patterns are practically identical; there are slight differences in some of the notes, but much of the apparent difference in the graphs is due to the difference in the quality of the two recordings.

The above cases represent what I believe to be instances in which the patterns are the same in different songs. In addition to these there are several other cases where two or more songs are almost identical and may represent variations of a basic general pattern; these are noted below.

6. The series represented by Plate 10, Figures 64 (164-IV, Worthington, Ohio) and 65 (431, Columbus, Ohio). The differences between these two patterns are very slight; the phrases in Figure 64 lack the first rather high note of those in Figure 65, and there are slight differences in the third and last notes of the phrases in the two patterns, but they are basically much the same. They sound alike to the ear.

7. The series represented by Plate 5, Figures 11 (428) and 13 (552), recorded about eight miles apart in Columbus, Ohio. These two sound alike, but note C in Figure 13 is lacking in Figure 11, and the first two notes of the phrase in Figure 11 (A and B) are represented by a single note (A) in Figure 13.

8. The series represented by Plate 7, Figures 31 (808B, Tallahassee, Florida) and 32 (854B, Myakka River State Park, Florida). These two patterns are very similar, differing only in the detailed character of some of the notes; the phrases are a little shorter in Figure 31 than in Figure 32. To the ear the former sounds a little faster; otherwise they sound alike.

9. The series represented by Plate 6, Figures 26 (172) and 27 (438) recorded about twenty miles apart in Franklin Co., Ohio. These two patterns are alike except for slight differences in the first and last notes of the phrase. The first note of the phrase is much stronger in Figure 27 than in Figure 26, and the last note is slurred a little differently in the two. These two songs sound alike to the ear.

10. The series represented by Plate 8, Figures 45 (828B-I) and

46 (868B), recorded about one-half mile apart in Myakka River State Park, Florida. These two patterns are very similar, differing only in the character of a few notes. The first and the last two notes of the phrase are a little different in the two series. These two songs sound only very slightly different to the ear; a casual listener would probably consider them identical.

The fact that there are only four cases in these recordings (Numbers 1, 2, 4, and 5, above) in which an identical song pattern was sung by different birds indicates that there is tremendous variation in the song patterns of this species. In 24 series recorded from one bird there were 22 different patterns; hence it appears that each individual has a considerable repertoire, probably considerably more than 22 patterns. The 22 patterns sung by this bird (wren M-4, Myakka River State Park, Florida) were sung over a period of a week; Saunders (Bent, 1948, p. 213) reports recording 36 different songs from one individual during a single season. There must be hundreds of different song patterns in this species.

SUMMARY

This study is based on 58 tape recordings of Carolina Wren songs made in six states; these recordings contained 71 song series and a total of 753 songs; 18 of the recordings, containing 24 song series, were of a single individual. Samples of each song series were analyzed by means of an audiospectrograph.

The singing rate varied from 4.8 to 13.3 songs per minute in one individual, and from 4.3 to 24.0 per minute in all the recordings; the average rate was 11.4 songs per minute. The singing rate averaged slightly higher in Florida birds than in Ohio birds.

The songs varied in length from 0.51 to 2.43 sec., averaging 1.66 sec. The songs of Ohio birds averaged slightly shorter than those of Florida birds.

The song of a Carolina Wren consists of a series of similar phrases. In most of the songs all the phrases were complete, but nearly a third had the last phrase incomplete, and in a few songs the first and/or last phrases were incomplete. Songs with the last phrase incomplete occurred more often in the recordings of northern birds than in those of Florida birds. In about four song series out of five all the songs were alike in phrase completeness. The variation in phrase completeness was approximately the same in the songs of one individual as in the songs of different individuals.

The recorded songs contained from 2 to 12 phrases, averaging 5.20 phrases, and the songs of one individual contained from 3 to

10 phrases. The songs of Florida birds contained, on the average, more phrases than those of Ohio birds.

The phrases varied in length from 0.169 to 0.620 sec. (from 0.195 to 0.480 sec. in the songs of one individual) and averaged 0.363 sec. On the average, the phrase length varied inversely with the number of phrases in the song. The phrases of Florida songs averaged shorter than those of the Ohio songs.

The phrases contained from 2 to 8 notes, averaging 4.58 notes. The Florida songs contained, on the average, somewhat fewer notes per phrase than the Ohio songs. In general, the longer the phrase the more notes it contained.

Most of the notes in the songs studied were slurred; a few contained portions that were steady in pitch and portions that were slurred. Some notes were musical and little or not at all slurred; a few were noise-like, containing a relatively broad band of frequencies. The songs of northern birds contained a higher proportion of slurred notes than the songs of Florida birds.

About one-fifth of the songs contained instances of two or more notes being uttered simultaneously; in most cases this resulted from one note continuing for a short time after the following note began, one of the notes usually being steady in pitch and the other slurred. A few notes contained steady and slurred elements simultaneously. At one point in each phrase of one song a steady note and two down-slurred notes were uttered simultaneously.

The frequencies in these songs varied from 1300 cps (approximately equivalent to the third E above middle C on the piano) to 7000 cps (approximately equivalent to the first A beyond the upper limit of the piano); this range occurred in the songs of one individual. The pitch range in individual songs varied from 10 to 25 musical intervals, and this range was not significantly different in the songs of birds from different localities.

The patterns of the wren songs studied were classified into four major groups on the basis of the pitch trend of the notes in an individual phrase of the song; each major group was further subdivided. The phrases of the songs in group I begin with a down-slurred note and have the pitch rising in the notes later in the phrase; in group II the general trend in pitch through the phrase is downward; in group III the pitch rises at the beginning of the phrase and falls later in the phrase; in group IV the phrase begins with a down-slurred note followed by an up-slurred note, the two notes covering a similar range in pitch. Of the 71 song series studied, 55 fell in group I, 3 in group II, 7 in group III, and 6 in group IV. There was little geographic variation in the song patterns of this species.

There were four instances in the 71 song series where two or more different birds sang songs that were identical or nearly so: (1 and 2) two birds in Florida, (3) a bird in Kentucky and one in Ohio, and (4) two birds in central Ohio. In five other instances the songs of two or three different birds were extremely similar but not identical. There were 22 different song patterns in 24 series sung by a single bird. There is evidently a tremendous variation in the song patterns of this species.

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A POX VIRUS OF THE SLATE-COLORED JUNCO

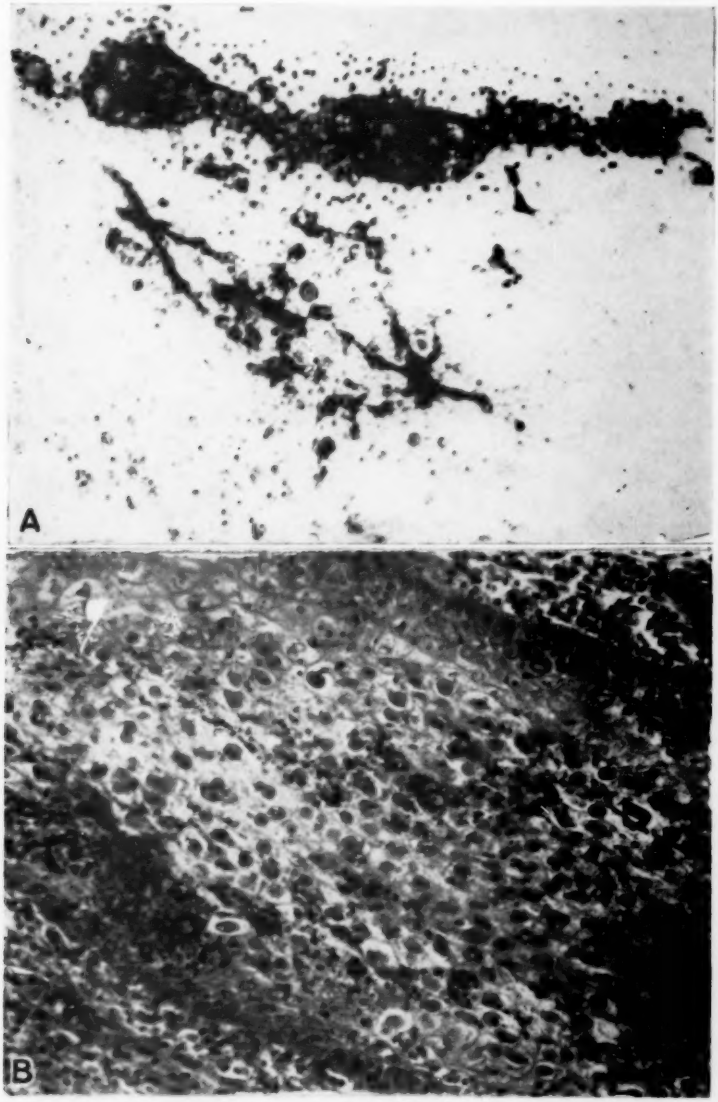
BY C. BROOKE WORTH

MUSSELMAN (1928) first reported foot-disease in Chipping Sparrows (*Spizella passerina*) and demonstrated that it could be transmitted by successively pricking the tumor-like lesion on the toe of a diseased bird and immediately pricking a healthy bird's toe with the contaminated needle. Although authorities have long suspected that the disease is caused by a virus, that fact has not heretofore been confirmed. This paper reports a demonstration of the viral etiology of "foot-disease" in a closely related species of bird and also characterizes some of the unique aspects of the virus. The work here reported was performed under the direction of Dr. Carl TenBroeck, while the author was Assistant in Animal Pathology at The Rockefeller Institute for Medical Research, Department of Animal and Plant Pathology, Princeton, New Jersey, on leave of absence from the Department of Biology, Swarthmore College, Swarthmore, Pennsylvania.

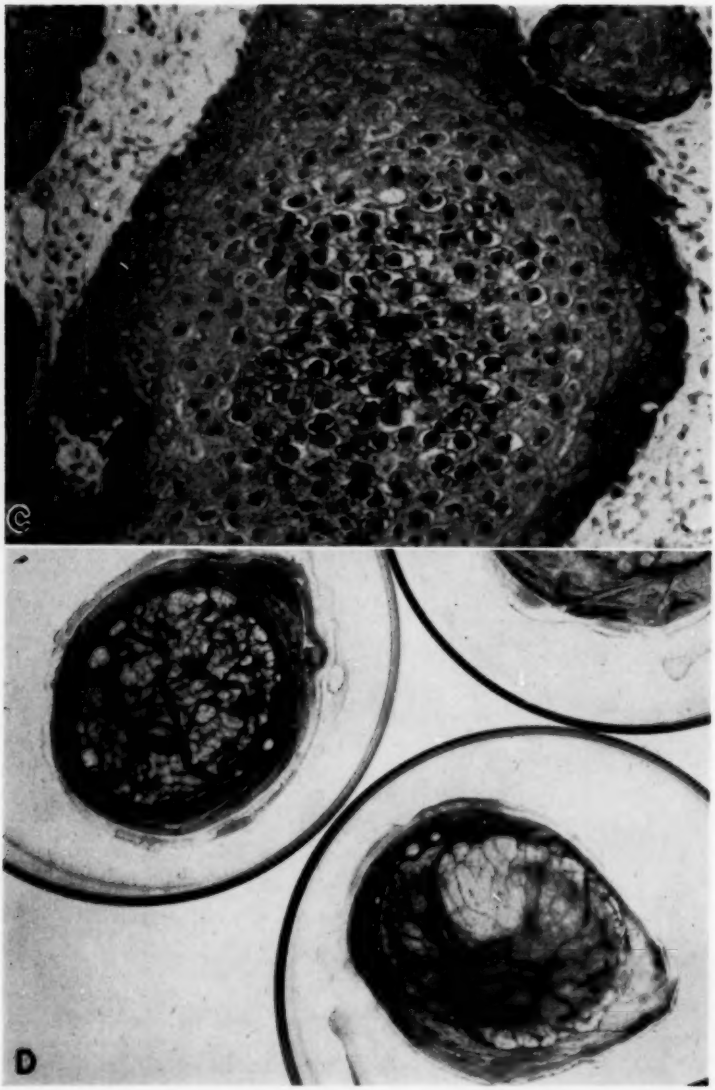
"*Foot-disease.*"—Bird-banders are almost universally familiar with foot-disease. It may be seen in a wide variety of small, ground-feeding birds, especially those of the finch family, and I have also observed it naturally (but infrequently) in the Blue Jay (*Cyanocitta cristata*), and even in the Chimney Swift (*Chaetura pelagica*). Although lesions may occur at the angle of the beak and elsewhere, they are located most typically on one or more of the toes. A lesion consists of an indurated swelling, up to 5 mm. in diameter, that becomes more or less spherical. After a week or two it may regress, or else it softens and breaks open. In the latter case secondary infection may lead to the loss of the toe, the foot, or the entire tarsus.

Isolation of the virus.—Late in 1939, an opportunity to study foot-disease in the Slate-colored Junco (*Junco hyemalis*) presented itself. A bird-trapping and banding station was established at Princeton, New Jersey, and as cold weather set in, many Juncos entered the traps. The observed incidence of foot lesions in these birds was about one per cent.

The diseased toe of one randomly selected Junco was incised and material within the nodule was suspended in one ml. of sterile physiological salt solution. This suspension was inoculated into: the toe pad of an apparently healthy Junco; the toe pad of a chicken; and some freshly denuded and scarified feather follicles of both a Junco and a chicken. The chicken's toe failed to respond, but a typical lesion was reproduced in the Junco's toe. The cutaneous follicles



A POX VIRUS OF THE SLATE-COLORED JUNCO. A. Elementary bodies in the chorio-allantoic membrane of the hen's egg. × 1500. B. Inclusion bodies in ectodermal cells of chicken skin. × 282.



A POX VIRUS OF THE SLATE-COLORED JUNCO. C. Inclusion bodies in hyperplastic ectoderm of embryonated hen's egg. × 235. D. Infected chorio-allantoic membranes of hen's eggs inoculated with Junco-virus. × 0.8.

of both the Junco and the chicken developed nodules that were indistinguishable from lesions of fowl-pox as commonly seen by poultrymen.

On the seventh day of its infection the chicken was killed and material from a follicular nodule was obtained aseptically from the flesh side of its skin. This matter was triturated, suspended in sterile physiological salt solution and deposited on the surface of the chorio-allantoic membrane of ten-day-embryonated hens' eggs. Seven days after inoculation the membranes showed discrete nodular opacities up to 5 mm. in diameter. The membranes were harvested, triturated, suspended in sterile saline solution and passed successively through nine additional series of hens' eggs. By this time the inoculation of undiluted membrane suspension caused a massive, confluent lesion of the recipient chorio-allantoic membrane, while discrete lesions could always be produced by suspensions diluted to 10^{-5} and sometimes to 10^{-6}.

Films from infected chicken skin and egg membranes, when stained by Morosow's silver-impregnation technique (1926), showed abundant elementary bodies (Plate 12, A). Histologic sections of the corresponding tissues revealed many ectodermal cells occupied by large intracytoplasmic inclusion bodies (Plate 12, B; Plate 13, C).

Suspensions of heavily infected egg membranes, when inoculated into Juncos' toes, caused the appearance of nodules resembling the initial lesion of the wild-caught Junco. The inoculum, incubated in broth tubes, failed to reveal bacterial contamination, nor was there detectable bacterial growth in hens' eggs after seven days' incubation.

It was concluded that the agent isolated from the Junco's toe was a virus of the pox-producing type.

Cross-immunity tests.—A suspension of Junco-virus was rubbed into freshly denuded and abraded feather follicles of several chickens. Another group of chickens was similarly infected with a strain of typical fowl-pox virus. All birds developed typical and identical follicular nodules. After one to three months, when the lesions had regressed, all birds were reinoculated at fresh cutaneous sites with the virus to which they had originally been exposed but also with the opposite virus. A third group of chickens, never exposed to either virus, was inoculated with both viruses simultaneously. The latter birds (controls) showed typical reactions to both viruses.

Chickens originally inoculated with Junco-virus showed no reaction to a second exposure to this agent but gave full reaction to fowl-pox virus. Chickens originally inoculated with fowl-pox virus showed no

reaction to a second exposure to this agent but gave slight or moderate reactions to Junco-virus.

Cross-immunity tests with other avian pox viruses were not performed.

Host range.—Typical cutaneous follicular lesions were produced by egg-membrane suspensions of Junco-virus in: squabs (*Columba livia*), a Blue Jay (*Cyanocitta cristata*), White-throated Sparrows (*Zonotrichia albicollis*), Fox Sparrows (*Passerella iliaca*), and Song Sparrows (*Melospiza melodia*). Lesions failed to appear in: unconfined adult pigeons (*Columba livia*), a Mourning Dove (*Zenaidura macroura*), nestling and adult Screech Owls (*Otus asio*), House Sparrows (*Passer domesticus*), Tree Sparrows (*Spizella arborea*), and a Laughing Gull (*Larus atricilla*). Lesions failed to appear also in laboratory rabbits, white mice, and a single human volunteer following shaving and scarification of the skin with subsequent exposure to a rich virus suspension.

Egg-membrane reactions. Macroscopic.—The most striking feature of the heavily infected egg-membrane, inoculated on the tenth day of incubation and harvested at seventeen to twenty days, was edema. Some membranes weighed as much as one-third of the embryo's bulk. The superficial blood vessels were frequently markedly dilated (Plate 13, D). Dehydration of an embryo sometimes led to its death. However chicks were hatched successfully from some heavily infected eggs, and these birds were found to be susceptible to cutaneous infection with Junco-virus at four months of age.

Microscopic.—Histologic sections of seventeen-day egg membranes showed extreme thickening and hyperplasia of the chorionic ectodermal layer (Plate 13, C). The mesoderm was greatly thinned out by the edema. No evidence of cellular infiltration could be seen, but this may have been because of the rarefaction of such elements by the edema. The endoderm showed no reaction. The ectodermal proliferation seemed to be most active at the deepest, or germinal, level, since this tissue buckled inward at many points, causing an appearance as of long, finger-like extensions of ectoderm invading the mesoderm.

Discussion.—The strain of Junco-virus here described differs from other known bird-pox viruses in several respects. That it has distant relationship to fowl-pox virus has been demonstrated by total cross-immunity in one direction but only partial cross-immunity in the opposite direction. Its behavior in embryonated hens' eggs also is at variance with the fowl-pox reaction, for the latter is fully evident by the third day, when the Junco-pox reaction is still only partially developed. Moreover edema is less evident in the fowl-pox reaction,

and the endoderm in fowl-pox-infected eggs may show hyperplasia with a few cells containing inclusion bodies (Woodruff and Goodpasture, 1931).

References in the literature to other avian viruses throw additional light on the unique nature of Junco-virus. Pigeon-pox virus produces the same reaction in hens' eggs as fowl-pox virus (Beaudette and Hudson, 1938). However the susceptibility of squabs but not "wild" adult farm pigeons to Junco-virus suggests that the adults may have had a pox disease that protects them from Junco-virus, so that Junco-pox may be related to pigeon-pox. Canary-pox virus cannot be transmitted to chickens (Lahaye, 1930; Kikuth and Gollub, 1932; Eberbeck and Kayser, 1932; Burnet, 1933). Virus from quail (species?) imported from Mexico that developed "epithelioma contagiosum" caused pock lesions in chickens but not as severe as those of ordinary fowl-pox (Gallagher, 1916).

Failure of Tree Sparrows to respond to inoculation with Junco-virus may reflect true immunity through prior exposure, since "foot-disease" was first recognized in Chipping Sparrows belonging to the same avian genus. But species immunity in the Tree Sparrow would be astonishing in view of the ability of Junco-virus to infect birds far removed from the Family Fringillidae.

Acknowledgement.—The assistance of Dr. John B. Nelson, who supplied the fowl-pox virus used in this investigation and also made valuable technical suggestions, is gratefully acknowledged.

Summary and conclusions.—A virus was isolated from a nodule on the toe of a Slate-colored Junco afflicted with "foot-disease." The virus was easily grown in chicken skin and in embryonated hens' eggs.

Cross-immunity tests in chickens with Junco-virus and fowl-pox virus indicated that the viruses, although possibly related, differ widely from one another.

The most characteristic effects of Junco-virus on the chorio-allantoic membrane of embryonated hens' eggs are: proliferation of the deeply-lying ectodermal cells and extreme edema of the mesoderm.

The host-range of Junco-virus was partially investigated. Squabs, a Blue Jay, and White-throated, Fox, and Song sparrows were successfully infected.

The behavior of the virus does not conform to reports on other bird-pox viruses in the literature, including fowl-, pigeon- and canary-pox viruses. However the susceptibility of squabs but not feral adult pigeons to infection by Junco-virus may indicate a relationship of this virus to pigeon-pox virus

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THE MIGRANT LOONS OF WESTERN PENNSYLVANIA

BY F. W. PRESTON

BENT (1919: 48) says of the Common Loon (*Gavia immer*), "The loons are apparently paired when they arrive on their breeding grounds, and I believe they mate for life." The implication would seem to be that they migrate as mated pairs.

Todd (1940: 32) says, "The loon is a rather solitary bird in our region (Western Pennsylvania), and a number together have a common interest rather than a sociable disposition. In the spring, however, presumably mated pairs may sometimes be encountered and on one occasion (May 1, 1932) Professor Seiple saw as many as twelve together on Conneaut Lake." This might be interpreted to mean that Todd construed Seiple's dozen as comprising six mated pairs, though I do not think Todd so intended it.

However, in conversation, Dr. Parkes of Carnegie Museum expressed the opinion that a considerable proportion of migrant loons may be moving in mated pairs, along with a lesser number of unmated birds. My own observations seemed to lend no support to this view, and on the contrary, tended to the opposite view, that all loons migrate as independent voyageurs, though sometimes assembling into fortuitous flocks of various sizes. It seemed advisable to submit the full evidence to such mathematical treatment as might be helpful on this point.

Material.—Western Pennsylvania from the West Virginia border north for a hundred miles or more, including the Pittsburgh area, contains few bodies of water attractive to loons: it is an upland country, much of it wooded, ranging in elevation from roughly 1,000 to 2,000 feet. None the less, the loons pass over it in some numbers, but they fly high, fast, and apparently silently, and are not often observed. I have seen one or two, traveling singly at a great height. The best opportunity to observe them is when they have alighted on some body of water, which happens frequently enough to give some idea of their behavior. The materials used in the present analysis are five years' observations at Oneida Dam, Butler County, in the years 1949 to 1953, inclusive. Most of the observations are my own, but some are by Mrs. Preston and others.

An account of the water birds of Oneida Dam, including all migrant species, for the first four of these years has been given elsewhere (Preston, in press), and a map of the area is there included. It is shown that in the four years in question, the peak of the loon migration came at April 22, the standard deviation (of the timing) was 11.6 days,

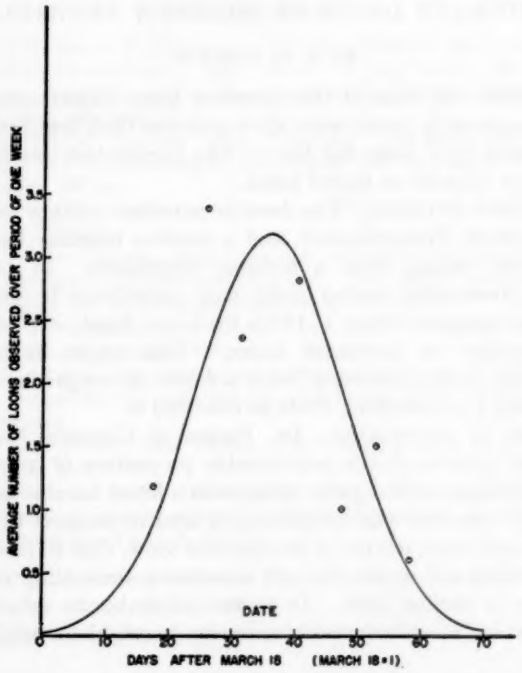

FIGURE 1. Gaussian curve fitted to the loon observations for 1949 through 1952. Vertex is at April 22; standard deviation, 11.6 days.

and the "effective" migration season extends from about April 1 to May 12, a period of six weeks. Figure 1, taken from that paper, shows the nature of the migration as a function of time, i.e., of the "season."

In 1953 a more meticulous watch was kept on the Dam, very few days being missed, and in Table I we report the number of loons seen on each day when a visit was made in the springtime of each of the five years. The 1953 observations add considerably to the total number of visits, and even more to the total number of loons; they also throw some light on the conditions producing good "loon days." But partly because the four years were treated separately in the previous paper and partly because lumping the 1953 observations with the rest might sometimes give undue weight to the behavior found in a single year (1953), a partial separation of the figures will be retained in the present paper.

TABLE I

LOONS SEEN AT ONEIDA DAM BY DATES

		1949	*1950*	*1951*	*1952*	*1953*			*1949*	*1950*	*1951*	*1952*	*1953*
March	18	0				0	April	22					1
	19	0	0		1	0		23		5			1
	20	0			0	0		24					1
	21	0	0	0	0	0		25					1
	22	0		0		0		26				2	
	23				0	0		27	6	1		0	
	24	0	0	0		0		28	3				
	25	0	0	0	0	0		29					0
	26		0	0		0		30					0
	27	0			0	0	May	1	1	0			2
	28	0				1		2					0
	29	0	0		0	1		3			3		1
	30		0	0	0	1		4	0		3		0
	31				0	2		5		0	0		0
April	1	2	1	1		6		6		0	2		0
	2	2			0	9		7					0
	3	3				1		8					0
	4	2				3		9					0
	5	2				1		10					
	6				0	53		11				3	
	7			0	0	0		12			1		
	8					1		13		0	1	0	1
	9	7				2		14			1		
	10	7		0		2		15					
	11		2	0		0		16					
	12		8			1		17					
	13	3	0	0	5	1		18			1		
	14	5	3	4		1		19					
	15		1	2	1	1							
	16	5				0							
	17		2	4		24							
	18			2		12							
	19			3		3							
	20	4	2		0	2							
	21					2							

The question to be decided is, primarily, do the loons migrate over western Pennsylvania in mated pairs? More broadly the question is, do the loons travel independently or in flocks? Here a pair can be considered a special or minimum size of flock. But it should be noted that a "pair" is not necessarily a "mated pair." The birds may not even be of opposite sexes, and since there seems to be nothing in plumage, size, or behavior to distinguish the sexes as we see the birds at Oneida, we have to be prepared for the possibility that two birds seen together may simply be a "random assemblage" of two.

The Odd/Even Ratio.—In the first four years, loons were seen on 41 occasions. On 25 occasions there was an odd number, and on

16 occasions an even number. In 1953, odd numbers were observed on 19 days, even numbers on 9. Now if *all* the birds were traveling in mated pairs, we should always see even numbers of birds. If they were all traveling independently, we ought to see odd numbers and even numbers about equally often. Since odd numbers predominate, we might draw the conclusion that the birds must all be traveling independently. There are, however, two hurdles to be crossed before this conclusion could safely be drawn. The first is an objection raised by Dr. Parkes in conversation. He said, "Let us suppose a reasonable number of birds are traveling independently. Then they ought to show up equally often in odd and in even numbers. Now add as many mated pairs as you like, and it will not change the ratio of odd to even occasions." This would be true if mated pairs never traveled on days when unmated ones didn't. It is not likely that this condition obtains, and if they do sometimes travel without unmated friends, then there will be a tendency for days of even numbers to predominate. Observations on this point can be made only at places where relatively few loons are assembled, places where "blank" days occur in the height of the season, for it is only at such places that adequate opportunities exist for mated pairs to put in an appearance in the complete absence of independently-traveling birds. Oneida meets the requirement, however, and lends no support to the argument.

The next hurdle is different. When a visit is made, in "loon season," and no loons whatever are seen, is the record to be ignored, as being neither odd nor even, or is the observation to be interpreted as showing an even number? For zero is certainly not an odd number, and in some cases is to be construed as even. This question permits us to raise the problem in a more precise form.

If the loons are all traveling independently, and all days are equally "attractive" during the migration season, then they should be distributed among these days in accordance with the terms of a Poisson Series. The probability of seeing none, one, two, three . . . loons will be given by the terms of the series

$$e^{-p}\left(1 + p + \frac{p^2}{2!} + \frac{p^3}{3!} + \text{etc.}\right) \qquad (1)$$

where p is the "average expectation" or "mean," and $p = Q/N$, Q being the total number of loons and N the total number of days "available" to them. Q may be taken as the total number of loons *observed* if we take N to be the total number of days that the observer was present and that were "available" or satisfactory to the loons.

Since the observer may be present at times before and after the main season, and since days very near the beginning and very near the end of the season must necessarily be less attractive or satisfactory to the loons than days near the height of the season, some uncertainty exists as to what is the proper estimate of N. It may even be contended that there is no proper estimate, but we shall for the present assume that there is a "fictive" value of N that can be found by not-too-arbitrary methods, and that it will serve our purpose. The evidence will be given later.

Equation (1) may now be dissected. The probability of our getting an odd number of birds is the sum of the terms

$$e^{-p}\left(p + \frac{p^3}{3!} + \frac{p^5}{5!} + \text{etc.}\right) = e^{-p} \sinh p \tag{2}$$

while the probability of our getting none, two, four, six . . . birds is

$$e^{-p}\left(1 + \frac{p^2}{2!} + \frac{p^4}{4!} + \text{etc.}\right) = e^{-p} \cosh p \tag{3}$$

The ratio of odd to even days is under these conditions

$$e^{-p} \sinh p / e^{-p} \cosh p = \tanh p \tag{4}$$

This assumes we count a "blank" day as an "even" day. If we do not feel sure how many days we ought to treat as blank, on the grounds above outlined, but are sure of the days when at least one loon was observed, then the ratio of odd to even days is

$$\sinh p/(\cosh p - 1) \tag{5}$$

In the above equations

$\sinh p$ is the "hyperbolic sine" of p, $= (e^p - e^{-p})/2$
$\cosh p$ is the "hyperbolic cosine" of p, $= (e^p + e^{-p})/2$
$\tanh p$ is the "hyperbolic tangent" of p, $= (e^p - e^{-p})/(e^p + e^{-p})$

The numerical values of expressions (4) and (5) are given below for several values of p. They are also graphed in Figure 2.

p (average expectation)	0.5	1.0	1.5	2.0	2.5	3.0
$\tanh p$	0.462	0.762	0.905	0.964	0.987	0.995
$\sinh p/(\cosh p - 1)$	4.1	2.16	1.57	1.31	1.18	1.11

In the first four years, 117 loons were observed on 41 days; that is, at least one loon was present on each of 41 days. The value of p, therefore, cannot exceed 117/41 or 2.85, and will be somewhat less according to the number of blank days we admit, p being defined as

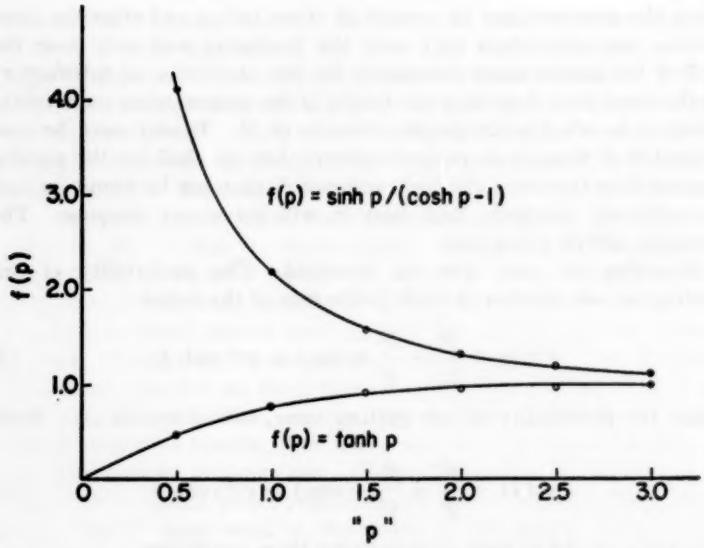

FIGURE 2. The Odd/Even Ratio. Functions tanh p and sinh p/(cosh p −1).

117/(41 + number of available but blank days). The ratio of odd to even days was 25/16 = 1.57, which corresponds to a p value of 1.5 loons per day. This means that we could allow many blank days and still be consistent with the hypothesis that all birds are traveling independently.

For the year 1953 the same general picture applies.

"Contagious" Distributions.—If loons fly in pairs, the departure, or arrival, of one loon entails the departure or arrival of another, its mate. This is the mildest form of "contagion." The term is familiar to plant ecologists in dealing with the number of individual plants that occur in a "quadrat." With many species, the individuals are "clumped," so that some quadrats have far more individuals than would be expected by random distribution. On the other hand, many plots are blank or nearly so.

If we assume that the pairs are the real units and that the behavior of a pair does not appreciably affect that of another pair, so that the pairs travel independently, then, subject to the conditions above specified with respect to the available days being intrinsically equal in attractiveness, we shall get a Poisson Distribution if we take the pairs as units. But if the units are really the pairs and we make the

mistake of assuming that the individuals are the units, we shall get a different sort of series.

It is frequently stated, and easily proved, that in a Poisson Series "the Variance is equal to the Mean," but in a contagious distribution the Variance exceeds the Mean. ("Mean" is the same thing as "Average Expectation.") By the same procedure it is easily shown that if the true unit is the pair and we mistakenly suppose it is the individual, we shall compute a Variance that is twice the Mean. In fact, more generally, if the true unit is a flock of m individuals and we make the mistake of taking the individual as a unit, we shall compute a Variance that is m times the Mean. (See, for instance, Arley and Buch, 1950.)

It may therefore be assumed that if we compute the Variance for our actual observations and divide it by the Mean, we shall get an estimate of the average number of birds in a flock. Once more, this depends on our being able to assign a satisfactory "fictive" number of available days in the four-year period, when the observer was, and the loons might perfectly well have been, present. If we take this figure as 45 days, the average expectation or Mean is 2.6, and the Variance is 3.77; so we might make a first estimate that the average size of the flock that acted as a unit was 3.77/2.6 or 1.45. The ratio is not very sensitive to the "fictive" value, and if we take the latter as 55 days (almost certainly a substantial over-estimate) the ratio rises only to 1.57.

Since this figure is substantially less than 2, it follows that a large proportion of the birds must be flying singly. We know that some are, because we have quite a number of days when a single loon is seen on the Dam. But the computation implies that even when we see more than one, they are often independent events.

We may now test this assumption. Suppose a substantial number of the birds are traveling in mated pairs, but another substantial proportion are traveling singly or in random aggregates, can the observations at Oneida be fitted to the assumption?

The prospect is not promising, for the assumption that *all* the birds are traveling in pairs would result in a series of peaks on the distribution curve (Figure 3) at the even numbers and a series of zeros on the odd numbers, and any combination of this with a normal Poisson Series (arising from the random distribution of birds that travel as independent individuals) would give a curve with humps at the even values and hollows at the odd ones. However, we may examine briefly the consequences.

Mixtures of Individuals and Pairs.—Let us assume that there are

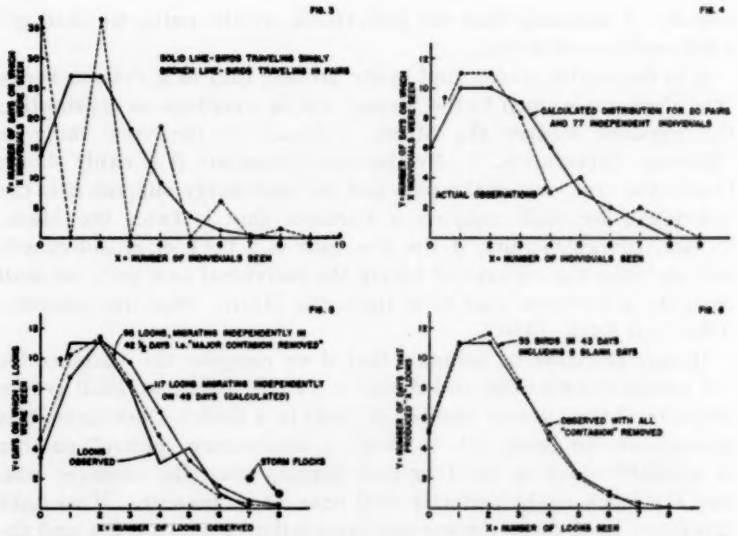
FIG. 3
SOLID LINE - BIRDS TRAVELING SINGLY
BROKEN LINE - BIRDS TRAVELING IN PAIRS
X = NUMBER OF INDIVIDUALS SEEN
FIG. 4
CALCULATED DISTRIBUTION FOR 20 PAIRS AND 77 INDEPENDENT INDIVIDUALS
ACTUAL OBSERVATIONS
X = NUMBER OF INDIVIDUALS SEEN
FIG. 5
117 LOONS MIGRATING INDEPENDENTLY ON 40 DAYS (CALCULATED)
LOONS OBSERVED
STORM FLOCKS
X = NUMBER OF LOONS OBSERVED
FIG. 6
93 BIRDS IN 43 DAYS INCLUDING 9 BLANK DAYS
OBSERVED WITH ALL "CONTAGION" REMOVED
X = NUMBER OF LOONS SEEN

FIGURE 3. Distribution to be expected if 100 birds are traveling singly or in pairs. FIGURE 4. Distribution to be expected if some loons are traveling in pairs and some singly. FIGURE 5. Distribution to be expected if all loons are migrating independently, major contagion removed or not removed. (See text.) FIGURE 6. Distribution to be expected if all loons are migrating independently, both major and minor contagion removed.

m birds per day traveling as independent individuals and n pairs of birds per day, making a total of $m + 2n$ individuals per day. If "contagion" is limited to the existence of mated pairs, the probability of our having 0, 1, 2, 3 . . . individuals contributed by the first group (those traveling as individuals) is given by the terms of the Poisson Series

$$e^{-m}\left(1 + m + \frac{m^2}{2!} + \frac{m^3}{3!} + \text{etc.}\right) \qquad (6)$$

Call these terms $M_0\ M_1\ M_2\ M_3$ etc.

The probability of our having 0, 2, 4, 6 . . . individuals contributed by the second group (those traveling in pairs) is given by the terms of the Series

$$e^{-n}\left(1 + n + \frac{n^2}{2!} + \frac{n^3}{3!} + \text{etc.}\right) \qquad (7)$$

Call these terms $N_0\ N_1\ N_2\ N_3$ etc.

Now the total number of birds observed is known: call it T. Then $\frac{mT}{m+2n}$ is the number of birds traveling solitarily and $\frac{nT}{m+2n}$ is the number of pairs traveling "contagiously." Call these figures T_1 and T_2 respectively. $(T = T_1 + 2T_2)$

Assume that the number of available days is Q, which figure we have to calculate from what follows. Then $m = T_1/Q$ and $n = T_2/Q$.

Then the *probability* of completely blank days is

$$M_0N_0 = e^{-(m+n)} = e^{-(T_1+T_2)/Q} \tag{8}$$

and the *number* of such days is

$$Q \cdot e^{-(T_1+T_2)/Q} \tag{9}$$

so that the number of non-blank days is

$$Q\,(1 - e^{-(T_1+T_2)/Q}) \tag{10}$$

But this number of days is known experimentally: it is simply the number of days on which one or more loons were actually observed. In order to limit ourselves as strictly as possible in the matter of arbitrary constants, let us suppose that the theoretical value must be identical with the observed value.

Then since T, the total number of birds accounted for theoretically must also equal the experimental (observed) total, the transcendental equation (10) can be solved for Q once we assign a value to T_1, the total number of birds traveling solitarily. This simultaneously assigns a value to T_2, and to m and n, though the values of the last two cannot be written down explicitly until Q has been found. Having solved for Q, we obtain m and n, and so obtain all the values M_0, M_1, M_2, M_3 . . . N_0, N_1, N_2, N_3 . . . in equations (6) and (7).

Now if we find, let us say, six birds present on a given day, these six may be (a) six individual birds and no pairs, or (b) four individuals and one pair, or (c) two individual birds and two pairs, or (d) no individual birds and three pairs. The combined probability of all these combinations is obviously

$$M_6N_0 + M_4N_1 + M_2N_2 + M_0N_3 \tag{11}$$

and similarly for any other number of loons we may encounter. The full tabulation is as follows:

Probability of a complete blank (zero birds) is	M_0N_0
Probability of a single bird	M_1N_0
Probability of two birds	$M_2N_0 + M_0N_1$
Probability of three birds	$M_3N_0 + M_1N_1$

Probability of four birds	$M_4N_0 + M_2N_1 + M_0N_2$
Probability of five birds	$M_5N_0 + M_3N_1 + M_1N_2$
Probability of six birds	$M_6N_0 + M_4N_1 + M_2N_2 + M_0N_3$
Probability of seven birds	$M_7N_0 + M_5N_1 + M_3N_2 + M_1N_3$

and so on. The total of all these probabilities, of course, adds up to unity, and if we multiply each probability by Q, the computed number of available days, we get the number of days on which we should theoretically have seen no birds, one, two, three, and so on.

The computations were made, for our four years, with several assumptions as to how the birds might be divided into individuals and pairs. For instance, if we assume that out of our 117 birds, 40 were in pairs and 77 flying individually, $T_1 = 77$, $T_2 = 20$, and $T_1 + T_2 = 97$, while the number of non-blank days was 41, so that our transcendental equation is

$$41 = Q\,(1 - e^{-97/Q}) \tag{12}$$

which we find by trial is satisfied when

$$Q = 47, \tag{13}$$

thus calling for six blank days.

Then

$$\left.\begin{aligned} m &= 77/47 = 1.64 \\ \text{while} \qquad n &= 20/47 = 0.426 \end{aligned}\right\} \tag{14}$$

Average Expectation $= m + 2n = 2.49 = 117/47$.

We can now formulate our two Poisson Series (6) and (7) in numerical terms, and find the values of the M's and N's, and from these in turn by the tabulation above, we can calculate all our probabilities and the number of days on which we ought to see none, one, two, three . . . birds. A rough slide-rule calculation comes out as follows, the values being given to the nearest whole day:

Number of loons	0	1	2	3	4	5	6	7	8	Total days
Number of days on which this number should be seen (calc.)	6	10	10	9	6	3	2	1	0	47
Observed number of such days	?	11	11	8	3	4	1	2	1	41 + ?

The agreement is fairly good, slightly better than on the assumption that all birds travel independently, but probably not significantly so. The results are graphed in Figure 4. It is quite obvious, from this and other computations not herein reported, that no assumption we can make as to the proportion of birds that might be traveling in pairs will produce any really great improvement over the assumption

that they are all traveling independently. There is *some "contagion,"* but the contagion is not that which arises from traveling in pairs.

The True Nature of the "Contagion."—From the calculations it became clear that the contagion arose almost entirely at the tail end of the distribution; there was one flock of seven birds that stayed for two consecutive days and hence was counted twice, and there was one flock of eight birds that stayed only one day. Removing these birds from the list reduces the total number of loons by 22, from 117 to 95, and the total number of non-blank days by 3, from 41 to 38. Solving for Q in the equation $Q(1 - e^{-95/Q}) = 38$ gives $Q = 42\frac{1}{2}$ days, and a comparison of the expected and observed results now reads:

Number of loons	0	1	2	3	4	5	6	7	8	Total days
Number of days on which this number should be seen (calc.)	4.6	10.2	11.4	8.4	4.7	2.1	0.8	0.3	0.1	38+4.6
Observed number of such days	?	11	11	8	3	4	1	0	0	38+ ?

The fit is now becoming very good. We have removed the *major* source of the contagion. See Figure 5.

Let us now make one other minor change: let us suppose that on two days when I saw five loons I ought to have seen only four. Then we have reduced the total number of loons to 93, and the number of non-blank days stays at 38. Proceeding as before we find $Q = 43$ days and our results are as follows:

Number of loons	0	1	2	3	4	5	6	7	8
Number of days on which this number should be seen (calc.)	4.96	10.71	11.59	8.35	4.51	1.95	0.70	0.22	0.06
Observed number of such days	?	11	11	8	5	2	1	0	0

The agreement is now virtually perfect. We have removed the *minor* source of the contagion. Figure 6 shows the comparison graphically.

The Variance and Mean of the Amended Observations.—With only the major contagions removed, the Variance is 2.32 as against a Mean of 2.23. With both major and minor contagions removed the Variance is 2.16 and the Mean also is 2.16, so that the amended observed series is in this respect a perfect Poisson Series to three significant figures.

The Odd/Even Ratio.—The expected odd to even ratio from the formula $\sinh 2.16/(\cosh 2.16 - 1)$ is approximately 1.26. The observed ratio for the amended series (both contagions removed) is 1.24.

Biological Conclusion.—Of the loons seen in the four years 1949–1952 inclusive, none were in pairs, approximately 80 per cent were in random assemblages, and 20 per cent in organized flocks.

Caveat.—The one point that would appear to be inadequately established in the foregoing is that it is legitimate to establish a "fictive" number of available days. If the loon season began sharply on a definite date (say April 1) and finished equally sharply on another date (say May 12), and all intermediate days were equally attractive or suitable for loon migration, then the Poisson Series ought to hold exactly, and the number of days (Q) is known without computation. It is simply the number of days on which visits were made. In the absence of any proof as to how legitimate the fictive method really is, we must assume that at best it can be only approximate, and that its almost exact fit is partly accidental. None the less, no modification that I can foresee is likely to increase the probability that the loons at Oneida Dam are in mated pairs on spring migration.

The Spring Migration of 1953.—The conclusions reached in respect of the four years 1949 to 1952 receive some confirmation from the figures for 1953, which were obtained after the analysis of that four-year period was largely completed, and hence are not included with them. In 1953 we visited Oneida every day from March 13 to May 9, except April 26, 27, and 28. No loons were seen before March 28, and none were seen after May 3, except that on one visit beyond the season, viz. May 13, one belated loon was seen. There were accordingly 40 days on which visits were made in what may roughly be called the loon season, which in previous years had covered essentially the same period. If we arbitrarily decide that the season terminated on May 4 this year, the number of visits "in season" was 35. In this period 117 loon-days were accumulated, the distribution of them among the various days being as follows:

Number of loons seen	0	1	2	3	4	5	6	7	8	9	12	24	53
Number of days on which this number was seen	12	15	6	2	0	0	1	0	0	1	1	1	1

The observations fall naturally into two groups: those days on which small numbers of loons were seen (0 to 4 or 5 loons) and those on which larger numbers were seen. In the first group there are 33 loons spread over 35 days. These loons behaved as if moving independently. However, there were also a few loons acting independently on days when larger numbers showed up. Thus there were really more than 33 "independent" loons and slightly more than 35 days on which they were observed (counting blank days).

Field notes report, as regards the assembly of 53: "27 in one flock, 20 in another, 3 in a third, and 3 separated individuals," and as regards the assembly of 24: "one flock of 11, one of 9, one of 2, and two singletons." As regards the flock of 6, the field notes say simply, "They

were not in pairs," but do not specify whether there was any apparent "clumping."

It is not practicable to deal at all rigorously with this information, but a first approximation may be made by assuming that on days when more than five birds were seen, *all* these birds were in flocks, and subject to "contagion," while the rest, 33 birds in all, were free from it. Assuming further that the 35 days on which these 33 birds were observed was a fair, but rough, estimate of the available "equivalent" days for them to be seen, the "average expectation" is 33/35 = 0.945. The Poisson Series is then as follows:

Birds seen	0	1	2	3	4	5	Total days
Days (calculated)	13.6	12.8	6.1	1.9	0.4	0.1	34.9
Days (observed)	12	15	6	2	0	0	35

The agreement is sufficiently good and would probably be even a little better if certain individual birds had not stayed around for more than one day. It seems probable that, in general, a single bird may stay more than one day, but if there are several birds and one gets the notion it would like to resume its journey, the contagion spreads to all the rest, so that sizeable flocks have little chance of remaining as long as twenty-four hours. Trautman (1940: 100) has in fact described exactly how the excitement is spread from a single bird to a whole flock. He says that a single bird rises from the water and flies at a low altitude, calling persistently, and one after another of the remaining birds join it and circle until an altitude of more than two hundred feet is reached, after which they resume migration. In his description there is no evidence of the birds acting in pairs, but his observations refer to the fall migration.

The "Storm Flocks."—The big flocks, or aggregates of flocks, at Oneida comprising 53 and 24 birds were forced down by bad weather; the flock of 12 probably was. The group of 6 was, and the group of 9 may have been. "Bad weather" here means heavy rain and mist, or a thunderstorm front coming in.

In no case is there any evidence that the birds are traveling in pairs. They seem to be traveling either singly or in flocks of some size. Mated pairs may, of course, be present in such flocks, but there is no evidence for it.

Few people, apparently, have seen 53 loons at once, and to see so many on such a small lake as Oneida Dam (approximately one mile long and a quarter mile wide) must be a still rarer event. It is clear that loons sometimes fly over us in considerable numbers but do not normally stop off. They go straight through unless forced down by

weather. The same thing has been observed to be true at Oneida Dam with many other species: wild swans, Horned Grebes, Ruddy Ducks, Old Squaws, and so on, which are seen only in very small numbers and very rarely, except when a storm forces them down, whereon they may be seen in dozens or even hundreds.

Trautman (1940: 100) observed essentially the same phenomenon at Buckeye Lake, Ohio. "More than half the transients observed were noted when cloudy and stormy conditions prevailed. The largest flock, of apparently one hundred and fifty birds, were observed to approach and light upon the lake during a severe wind and rainstorm . . . Nov. 2, 1927."

It is tolerably clear, therefore, that our loons may properly be divided into two categories: those that arrive in any sort of weather, more or less normal weather as a rule, and those that alight to avoid flying through severe fog and rain. The former are flying as individuals or strictly random assemblages and appear on the Dam only in very modest numbers, up to about half a dozen at any one time. The latter, the storm birds, may appear in large numbers, and their arrivals must be treated as freak or exceptional events. Such events will not fit into any mathematical pattern until a very large number of such events has been observed, and this would require perhaps a century of watching. They are legitimately removed from consideration while we investigate the pattern of the normal events.

The Control Chart Technique.—In industry there has developed in the last decade or two, a widespread use of the "Control Chart," which was introduced by Shewart (1931). It depends on the same basic statistical concepts but is operated in a routine fashion which is superficially quite different from the methods commonly used by biologists. Accordingly, I reported to one of my associates, Dr. L. G. Ghering, who has much experience in working with these charts, that over a period of some weeks, a number of "defects" had occurred in an industrial operation, and would he set up a control chart and see what had been going on? The "defects" were actually the number of loons per day at Oneida Dam, but he did not know that, and the sequence of figures was compiled by taking the data from March 28 to May 12, inclusive, for all five years combined. Thus a sequence might be April 1, 1949; April 1, 1950; April 1, 1951; April 1, 1953; April 2, 1949; April 2, 1952; April 2, 1953; and so on. The date was not provided, only the sequence of observations. Zeros (blanks) were reported in their proper position in the sequence, but nothing was reported about days on which no visit was made.

When the control chart was prepared, it rejected as abnormal all

observations of more than 7 individuals, that is, those days on which 9, 53, 8, 24, and 12 loons were observed, a total of five observations out of ninety-seven. Days with seven individuals were borderline cases. In industrial practice such events are due to "assignable causes": if you go into the factory, you will find that something has "gone wrong," and you will be able to find what it is. In our case we go into the field, and find what it is, viz., a storm. The other observations are regarded, in industrial operation, as the "normal" day-to-day variations, due to many causes, which are not worth tracking down or incapable of being tracked down.

Thus, the Control Chart Technique agrees with our own investigations.

The Validity of the "Fictive" Number of Available Days.—There are some days, those outside the loon season, for instance, when it is quite unlikely that we shall see a loon at all, and there may be days within the loon season which for some meteorological reason are unlikely to produce a loon, just as there are occasional days that produce an unreasonably large number of loons. However, during the height of the season we might expect that most days are suitable, perhaps roughly equally suitable. The crest of the Gaussian Curve, the height of migration, is (for the first four years) at April 22. Let us assume that this is true enough for the whole five-year period, and accordingly let us take the week ahead of April 22 and the week that follows it, as the period in which all days might be expected to be equally suitable for migration. In the five-year period twenty-six visits were made to Oneida Dam in these two weeks (the period from April 15 to April 28, inclusive), and a total of 55 loons was seen, excluding those that appeared in numbers exceeding seven on one day. The average expectation is accordingly $55/26 = 2.12$, and we can compute their apportioning among the twenty-six days on the assumption that it was random.

Number of loons seen	0	1	2	3	4	5	>5
Calculated number of days	3.1	6.6	7.0	4.9	2.6	1.1	0.7
Observed number of days	3	8	7	3	2	2	1*

* Observed number of loons was 6.

Clearly the agreement is good (the variance is about 2.5 instead of the exact value 2.12), and we are justified in assuming that "normal" loons, those that arrive in the absence of storms, are random assemblages.

Note that in this calculation we have not allowed ourselves any leeway whatever in the way of adjusting the "blank" days. Our computation is based on the actual number of visits, including the

unproductive ones, and the actual count of loons. We may, therefore, feel some confidence that we reached the right conclusion in the more general case, the whole of the loon season, in spite of the fact that we had to estimate the number of genuinely blank days. This "estimate" was made, it will be recalled, not arbitrarily, but by a rigorous mathematical treatment of the days that were *not* blank, and it appears that we were not far wrong.

In conversation, Dr. Parkes commented that the question whether loons are paired on migration is a biological rather than a mathematical matter, and that it ought to be capable of being decided on that basis. From the field evidence as we see it at Oneida Dam, it would not have occurred to me to suppose that any of them were in mated pairs. It is only the comments in the literature, by Bent, Todd, and others, that raise the question. Trautman, in his work on the birds of Buckeye Lake, gives no indication of suspecting that the loons there were mated pairs, and in a private communication (1954) he writes as follows:

"I have no recollection of having seen Loons obviously paired during actual migration, in either fall or spring. On the whole, loons did more calling in spring than in fall at Buckeye Lake but they never conspicuously associated in pairs. This was likewise true for southern Michigan immediately south of their normal breeding grounds. When the loons arrived on their breeding grounds in Michigan, they did much calling and flying from one lake to another. I have always believed that the calling birds were looking for mates and that when a lake and mate were chosen the birds thereafter occurred in pairs. . . . It is my belief that if Loons do pair during migration the pair are not attentive to each other as are such species as the Black Duck, and that pairing as such is infrequent or sporadic until the birds reach the breeding grounds."

Dr. Gudmundsson of Reykjavik, Iceland, tells me that no lake, even quite a large one, contains more than one pair of breeding loons: each pair demands a lake to itself, and other observers have told me the same thing. On this basis, loons ought to run short of lakes long before they run short of food. Dr. Parkes comments that there may be an abnormally large pool of non-breeding birds in this species, and that the presence of great numbers of loons on a single lake in Manitoba in the breeding season seems to confirm this. (Rand, 1948).

I should like to acknowledge my indebtedness to Dr. R. C. F. Bartels of the University of Michigan for looking over this paper and for supplying the reference to Arley and Buch (1950). His help has

permitted a substantial condensation of the mathematical treatment of the subject.

Conclusion.—There is no evidence that the loons we normally see in central western Pennsylvania ever travel in mated pairs on spring migration. If mated pairs fly over us, they either never stop off, or their identity is lost in the large flocks that we see only very occasionally. There is not enough evidence to disprove their existence entirely, but there is at present no evidence whatever of their existence in our region.

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FOOD HABITS OF THE KING RAIL IN THE ARKANSAS RICE FIELDS

BY BROOKE MEANLEY

THIS paper on the food habits of the King Rail (*Rallus elegans*) is a continuation of a life history study of this species in the Arkansas rice fields (Meanley, 1953). Specimens and data on feeding behavior were obtained from 1950 to 1955. Most of the stomachs representing the nesting season were taken from dead rails found along local highways; winter specimens were furnished by Carl Kitler, local mink trapper who caught about one a day along his trap line.

I am indebted to U. S. Fish and Wildlife Service co-workers E. R. Kalmbach, Alexander C. Martin, Robert T. Mitchell, and Francis M. Uhler for the identification of several food items found in gizzards; and to Dr. Martin, Johnson A. Neff, Charles C. Sperry, and Robert E. Stewart for reviewing the manuscript.

Feeding Behavior.—During April, May, and early June it is not unusual to see 15 or 20 King Rails in the evening feeding along ditches bordering certain highways leading out of Stuttgart, Arkansas. After the middle of June, the rails move out of the roadside ditches and canals into adjacent rice fields where they are found until harvest. During the winter they are found about the network of rice field canals and natural drainage, spending much of their time along runways beneath matted vegetation.

The most active feeding periods appeared to be in the early morning and the late afternoon or evening, usually till dusk. Rails were also found to feed sporadically throughout the day, tapering off or stopping for short rests during periods of intense heat. I once kept a pair of rails under constant observation for 2 hours while they fed in the vicinity of their nest during the middle of the day. The feeding bird passed back and forth near the nest and often came within a few inches of its incubating mate. On other occasions individuals seen feeding steadily for a half hour or more along a ditch during the heat of midday in June stopped under a tussock of grass and remained motionless for from 5 to 20 minutes before resuming activity.

Rails do most of their feeding in places concealed by plant cover or in relatively open areas where they blend well with their surroundings. Occasionally, however, the birds are very conspicuous, as when feeding on mud flats or in recently flooded fields where rice sprouts are 3 or 4 inches in height. W. Leon Dawson (1903: 443) observed similar rail-feeding activity in open areas in Ohio: "In a region where

they were in little fear of molestation, I have seen them deploy upon an extensive mud flat in broad daylight and go prodding about in company with migrant sandpipers, for the worms which riddle the ooze with their burrows."

The King Rail feeds almost exclusively in rice fields during the summer. About the only time it emerges from this cultivated marsh type is when it moves from one rice field to another or comes to the edge of a gravel road to obtain grit. When a field of nearly mature grain is drained preparatory to harvesting, the rails move over to a field of younger rice, often contiguous to the dry field. Some rice fields have a few low, wet spots which prove attractive to rails even up to harvest time; but the last feeding place in nearly all drying rice fields is along the "borrow" or ditch bordering the levee. King Rails, Virginia Rails (*Rallus limicola*), and Soras (*Porzana carolina*) continue to feed along these ditches while they contain water until the field is harvested.

Generally, King Rails forage in water so shallow that only the bill, or part of it, disappears beneath the surface while food is sought. However, on March 25, 1954, I observed a pair of rails feeding in a roadside ditch where the water varied from 6 to 12 inches in depth. Both of these birds immersed their entire heads and necks in the water, and several times their entire bodies disappeared beneath the surface. In fact, they occasionally fed by "tipping up" like dabbling ducks.

This typical bird of the rice country performs a service to the rice grower by consuming large numbers of crayfish (*Cambarus*) that bore holes in rice field levees. These crustaceans are usually torn apart and eaten in the course of several minutes; in one case the dismantling operation was timed at 7 minutes. On another occasion, within several seconds after a crayfish was caught by a rail and the bird was still holding it in its bill, another rail, presumably its mate, rushed up, grabbed the crayfish and swallowed it whole.

An interesting food habits note was recorded on June 3, 1954. From an observation post, 30 feet from a King Rail nest, I saw the brooding bird pick up a complete egg shell and devour about three-fourths of it. This occurred about 5 minutes after the egg had hatched. This incident may explain the occurrence of King Rail egg-shell fragments as 85 per cent of the contents of a stomach collected at Stuttgart on May 11, 1953.

Feeding Activity of Young.—Laboratory analysis revealed food in the stomachs of several King Rail chicks less than one day old. Nests of newly hatched King Rails were examined for clues to the source of this food. In several such nests small regurgitated pellets

about one-half inch in diameter were found. These pellets usually were composed of finely ground fragments of crayfish and aquatic insects similar to material found in the young rails' stomachs. I believe that young rails one day or less old feed upon these small regurgitated pellets. This type of feeding behavior has been recorded for young Little Blue Herons (*Florida caerulea*) less than three days of age, which fed upon pellets regurgitated by their parents (Meanley, 1955).

A pair of King Rails may remain with their brood for more than a month after hatching. I have collected young rails three-fourths grown that were still traveling with an adult pair in early August. In several instances a pair of rails with their two-weeks-old brood were observed feeding within 50 feet of their nest. Once I came upon a brood of young King Rails approximately three weeks old that was traveling with three adult birds.

Food.—Animal life comprised 79 per cent of the King Rail's year-round diet. It constituted 90 per cent or more in spring and summer; then dropped to 74 per cent in the fall (the fact that the bulk of the

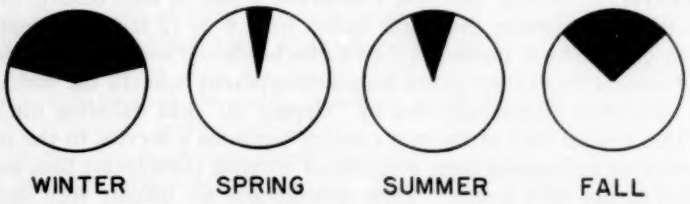

FIGURE 1. Seasonal variations in proportion of plant (black) and animal (white) food of the King Rail in Arkansas rice fields.

fall series of stomachs was collected in November may have made this figure lower than if there had been better representation of the early part of this season); and was still lower (58 per cent) in winter.

The shifts in feeding grounds (from roadside ditches in the spring to rice fields in summer and early fall, and finally back to natural drainage ditches and small marshes of cattail, *Typha latifolia*, in winter) may account for some of the seasonal variations in food. However, natural seasonal fluctuation in abundance of aquatic animal life is apparently the basic explanation for most of these differences in diet.

The crayfish is an outstanding food of the King Rail, constituting 23 per cent (by volume) of the diet on an annual basis. In spring it forms 61 per cent; in summer, 22 per cent; in fall, 3 per cent; and

in winter, 7 per cent. Crayfish are available the year round and constitute a staple food of this rail. It appears probable that consumption of this crustacean is influenced as much by the availability of other favorite foods as by the abundance of crayfish. Possibly seasonal variation in the size of the crayfish, its agility and/or palatability according to age may also be factors bearing upon its extent of seasonal use by the rail.

Another staple food available at all seasons is fish. It amounts to 26 per cent (by volume) of the King Rail's food in the fall when many fish have become impounded in the shallow borrow pits of drained rice fields and are easy prey for the foraging birds.

Aquatic insects are important foods, especially certain aquatic beetles and water bugs which are available the year-round. Dytiscids furnished 19 per cent of the winter diet. They are more abundant in rail habitat at all seasons than hydrophilids.

Land beetles, chiefly ground beetles (Carabidae), scarabs (Scarabaeidae), and snout beetles (Curculionidae) made up 6 per cent of the rail's food, and grasshoppers (Orthoptera) constituted 7 per cent.

A wide variety of other insects was taken in small quantities. During the summer and fall this formed 8 per cent and 5 per cent, respectively, of the rail's food. Among these insects were dragonfly (Odonata) nymphs, back-swimmers (Notonectidae), horsefly (Tabanidae) larvae, fall army worms (*Laphygma frugiperda*), rice water weevils (*Lissorhoptrus simplex*), and rice stinkbugs (*Solubea pugnax*).

Frogs accounted for about 4 per cent of the food. Unusual animal food items (listed in Table 1 as "Miscellaneous") found in King Rail stomachs were skunk (*Mephitis*) hair, feathers and vertebrae of a female Redwing (*Agelaius phoeniceus*), King Rail egg shell fragments, a small water snake (*Natrix*), and a shrew (*Sorex*).

The King Rail apparently is more of a vegetarian than its salt marsh relative, the Clapper Rail (*Rallus longirostris*). Of the former, Audubon (1835: 29) states that, "When grown they feed on a variety of substances, and it has appeared to me that they eat a much greater proportion of seeds and other vegetable matter than the Salt-water Marsh-hens." John Oney (1954), in his study of the fall food of the Clapper Rail along the Georgia Coast found that plant materials constituted only trace items of the Clapper's diet at that season. Martin, Zim, and Nelson (1951: 82) found the volume of plant food in the Clapper's diet to be as follows: winter, 11 per cent; spring, 1 per cent; summer, 0 per cent; and fall, 3 per cent. In the Arkansas area vegetable matter in the diet of the King Rail made up the following volumetric percentages during the 4 seasons: winter (33 stomachs)

TABLE 1

PRINCIPAL FOODS OF THE KING RAIL IN THE ARKANSAS RICE FIELDS

	Winter (*December–February*)		*Spring* (*March–May*)		*Summer* (*June–August*)		*Fall* (*September–November*)		*Annual*
	33 stomachs		*48 stomachs*		*16 stomachs*		*21 stomachs*		*118 stomachs*
	per cent by volume	*per cent by occurrence*	*per cent by volume*	*per cent by occurrence*	*per cent by volume*	*per cent by occurrence*	*per cent by volume*	*per cent by occurrence*	*per cent by volume*
ANIMAL	58	249	95	252	90	412	74	300	79
Invertebrate:									
Crayfish	7	18	61	81	22	25	3	5	23
Aquatic beetles	20	76	7	21	19	31	10	48	14
Land beetles	1	13	8	56	11	87	4	38	6
Grasshoppers	5	24	3	8	6	63	14	57	7
Aquatic bugs	5	24	1	15	10	44	6	29	6
Other insects	tr.	21	2	17	8	75	5	38	4
Spiders	tr.	3	tr.	2	tr.	13	1	10	tr.
Snails	3	12	2	8	tr.	6	tr.	10	1
Vertebrate:									
Fish	7	30	1	21	8	19	26	43	11
Frogs	5	21	4	15	5	50	4	24	5
Miscellaneous	5	7	6	8	—	—	—	—	3
PLANT	42	109	5	25	10	87	26	76	21
Rice	30	52	4	19	10	31	21	29	16
Rice field weed seeds	tr.	36	tr.	4	tr.	56	2	38	1
Woody plant seeds	—	—	1	2	—	—	3	10	1
Tubers	12	21	—	—	—	—	—	—	3

42 per cent; spring (48 stomachs) 5 per cent; summer (16 stomachs) 10 per cent; and fall (21 stomachs) 26 per cent.

Cultivated rice (*Oryza sativa*) seed is taken in larger quantities than any other plant food. It formed 16 per cent of the annual diet. Increased rail consumption of rice seed during fall and winter no doubt is due to the abundance of waste grain left in the stubble. Kalmbach (1937) in his study of the food of the Gulf Coast Redwing (*Agelaius phoeniceus littoralis*) suggests that the hard siliceous hulls of rice seed may be used for grinding purposes.

Rice field weeds, abundant in all rail habitats, furnished some food to rails throughout the year. Seeds of jungle-rice (*Echinochloa colonum*), wild millet (*Echinochloa crus-galli*), bullgrass (*Paspalum boscianum*), rice cutgrass (*Leersia oryzoides*), beakrush (*Rhynchospora*), and smartweeds (*Polygonum*) were found as traces in many stomachs, in each season except fall when they composed 2 per cent of the contents.

The following seeds of woody plants were found in individual stomachs: blackberry (*Rubus*), snowbell (*Styrax americana*), blackgum (*Nyssa sylvatica*), and oak (*Quercus*). Tubers of marsh plants (probably sedge) were found in several stomachs, and one rail had eaten tubers of an arrowhead (*Sagittaria*).

SUMMARY

A study of the food habits of the King Rail in Arkansas rice fields has been based on analysis of 118 gizzards and numerous field observations from 1950 to 1955.

During the cooler months, rails fed mostly about the network of rice-field canals and natural drainage, while in summer the feeding was largely in rice fields. The periods of most active feeding appeared to be early morning and late afternoon or evening.

Animal life comprised 79 per cent (by volume) of the King Rail's food. Crayfish were the principal item, constituting 23 per cent of the annual diet. In the fall, fish impounded in pools of drying rice fields became readily available and furnished 26 per cent of the fall season's food. Dytiscids were important in the winter diet, amounting to 19 per cent of it, while various beetles, grasshoppers, and numerous other insects provided most of the remainder of food used.

Of the 21 per cent of plant food taken, cultivated rice seeds were the dominant item. Seeds of rice-field weeds were eaten frequently but generally constituted traces in the total bulk of food.

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DYNAMICS OF RANGE EXPANSION OF CATTLE EGRETS IN FLORIDA

BY DALE W. RICE

AFRICAN CATTLE EGRETS (*Bubulcus ibis ibis*) were originally confined to the Old World. Following an increase and expansion of range in Africa since 1900 (Skead, 1952), they colonized northeastern South America about 1930 (Haverschmidt, 1950, 1953; Dugand, 1954). In 1948 they invaded North America (Sprunt, 1953) and are now well established and abundant in Florida around Lake Okeechobee. In the past twenty years Indian Cattle Egrets (*B. i. coromandus*) have also spread from the Moluccas to New Guinea and Australia (Peterson, 1954). This has offered a unique opportunity to study a species during a period of rapid range expansion. Much is still unknown about this process, partly because the birds have not previously been studied during the initial phases of their establishment in a new region.

During the spring and summer of 1954, I was fortunate enough to witness the first appearance and nesting of Cattle Egrets in North Florida, a region where they did not previously occur and which is 180 miles from the next-nearest nesting colony. My observations help to fill some of the gaps in our knowledge of the process of range expansion and lead to some interesting ecological, ethological, and zoogeographical speculations.

David K. Caldwell, Thomas W. Hicks, Edwin H. McConkey, Edward L. Mockford, and Minter J. Westfall assisted me in the field on numerous occasions. Fred D. Bartleson generously made his own records available to me. Archie Carr and the late W. C. Allee read the manuscript and offered many valuable suggestions.

The observations reported herein were made at Lake Alice, one half mile southwest of Gainesville, Alachua County, Florida. This lake is the site of a large heron and ibis colony. A low shrubby swamp consisting of red maple (*Acer rubrum*), willow (*Salix longipes*), buttonbush (*Cephalanthus occidentalis*), and elderberry (*Sambucus simpsoni*) covers much of the lake's 90 acres; the remainder consists of open water, dense mats of water pennywort (*Hydrocotyle* sp.), and small patches of flag (*Typha, Sagittaria, Pontederia*) marsh. There is a fringing swamp of tupelo gum (*Nyssa biflora*).

The following species of birds nest in the colony, arriving in early March and leaving gradually in the late summer and autumn. A few remain all winter. The figures indicate the number present (maximum counts of the evening flights) in 1954 prior to the nesting

season; the total is approximately doubled when the young are on the wing.

Water Turkey (*Anhinga anhinga*)	100
Great Blue Heron (*Ardea herodias*)	4
Greater Egret (*Casmerodius albus*)	44
Snowy Egret (*Leucophoyx thula*)	505
Tricolored Heron (*Hydranassa tricolor*)	52
Little Blue Heron (*Florida caerulea*)	276
Cattle Egret (*Bubulcus ibis*)	6
Green Heron (*Butorides virescens*)	5
Black-crowned Night Heron (*Nycticorax nycticorax*)	12
Yellow-crowned Night Heron (*Nyctanassa violacea*)	15
White Ibis (*Eudocimus albus*)	2200
Eastern Glossy Ibis (*Plegadis falcinellus*)	56

Most of these birds, along with Wood Storks (*Mycteria americana*) and Sandhill Cranes (*Grus canadensis*), feed about three miles south of the colony on Payne's Prairie, a 13,000-acre wet prairie and marsh used for cattle pasture. Such prairies are characteristic of much of southern and southeastern Alachua County and adjacent parts of Marion and Putnam counties and are vegetationally and faunistically similar to, but isolated by many miles from, the prairies and marshes of the upper St. Johns River, the Kissimmee Valley, and Lake Okeechobee, the last being the only other area in North America where Cattle Egrets are known to nest.

Observations by Karraker (1953) and Benjamin B. Leavitt (unpublished) have proven beyond reasonable doubt the absence of Cattle Egrets in this area prior to 1953.

1953.—I first began regular field work in Alachua County in February, 1953. I am certain that no Cattle Egrets were present during most of that year, for the following reasons: I visited the Lake Alice colony almost weekly during the spring and early summer; I was always alert for Cattle Egrets and could not have missed them if they had been using the colony. During the summer and autumn I looked at thousands of egrets on Payne's Prairie, now the Cattle Egrets' feeding area, and saw none there. Having a special interest in the symbiosis between Snowy Egrets and cattle, I carefully observed every egret I saw associating with cattle and found no Cattle Egrets.

The first Cattle Egret seen in North Florida was found by Fred Bartleson on 20 November in a roadside ditch just north of Payne's Prairie.

1954.—I first noticed that the herons and ibises had returned to the Lake Alice colony on the evening of 11 March. On 25 March, I made the first census of the evening flight and saw three Cattle

Egrets; at least one was an adult beginning to assume nuptial plumage. On subsequent weekly visits I counted up to a maximum of six Cattle Egrets. On the evening of 29 April, six were seen, two of them in full nuptial plumage, three in partial nuptial plumage, and one in winter plumage. Earlier observations indicated the presence at that time of one additional bird in winter plumage. This makes a total pre-nesting population of seven, a figure supported by subsequent observations.

Since certain of the Cattle Egrets in full nuptial plumage centered most of their attention on a single clump of bushes, I suspected they might be nesting. On 2 May, I began searching for nests and soon located one by watching the adult birds and following them when they went to feed their nestlings. This nest was in a red maple about four feet above the water. The three young birds which it contained were well covered with down; I estimated that they were between two and three weeks old. This indicates that laying took place between 20 and 30 March. In the same clump of bushes with the Cattle Egrets' nest were nests of Snowy Egrets, Little Blue Herons, and Tricolored Herons. I examined the nest again on 5 May, but the young had not changed noticeably.

On 22 May, the nest was empty. On that date I saw two nearly fledged juvenile Cattle Egrets perched on a bush near the nest site. I am not certain that they came from the same nest. From the behavior of the adult birds, I suspect that there was a second nest nearby.

During subsequent weeks I did not look for additional nests, assuming that the nesting season was over. The difficulty of finding and identifying nests when the adults are not feeding nestlings also helped prevent my finding any more. However I continued seeing the Cattle Egrets every week during the evening flights to the colony and noticed that most of the adults remained in full nuptial plumage well into July. During this period I counted a maximum of seven Cattle Egrets, including at least one young of the year.

On 25 July I discovered two more nests by watching the adults feed the young birds. One was in a buttonbush three feet above the water and contained two nearly fledged young. The other was in a nearby buttonbush two and a half feet above the water and contained two young birds slightly younger than those in the neighboring nest. These were probably second nestings; laying had evidently taken place about the end of May. On 28 July the young from the former nest were perched in the bushes above the nest; the young were still on the latter nest. Both broods were still being fed by the

parents. On 29 July the young were gone from the former nest; one fully fledged immature bird was seen at the colony. On 4 August two immature birds, one of which was perhaps unfledged, were there.

On the morning of 28 July, I watched the birds depart from the colony. I saw twelve Cattle Egrets. Four were in nuptial plumage and were the parents of the nestlings in the two nests. Three adults were in non-nuptial plumage. One bird was a fully-fledged juvenile, probably the one observed earlier in the evening flights and probably from the earlier nest. The other four were the four nestlings. Unless there were additional immature birds present from the first nest (or nests), these twelve birds were probably the total population at the close of the nesting season.

I continued to observe Cattle Egrets in the evening flights later in the summer. At least one adult in full nuptial plumage was present as late as 26 August; on that morning I watched it for over an hour, and it gave no indication of having a nest or dependent young. At least two adults in non-nuptial plumage were also seen that day.

Although these data are too meager to use in drawing conclusions regarding nesting success, it is probably not significantly different from that of the other small herons using the colony, nor different from that of Cattle Egrets in Spain (Riddell, 1944: 505), where they have always occurred in abundance.

1955.—The Cattle Egrets arrived at the colony on 11 April, when I counted five in the evening flight.

On 29 April, I counted seven Cattle Egrets. Three were in nuptial plumage; the other four, presumably year-old birds, were in non-nuptial plumage. I found two nests, and from the behavior of the birds I am certain that one more nest was present, making a total of three nests. Since the four birds in non-nuptial plumage undoubtedly were not breeding, it can safely be assumed that three additional breeding adults were present. This makes a total of ten Cattle Egrets at the colony.

I left Florida in the early summer of 1955, so have no data on the fate of these nests, or on second broods.

Range expansion is dependent on the ability of a species to disperse to unoccupied areas, which may require crossing distributional barriers, and on its ability to establish itself in new areas. Each of these factors may be discussed separately.

Dispersal.—Two questions regarding dispersal must be answered: Where did the birds come from? And why did they move to the Lake Alice region, across 180 miles of territory where the species is unknown?

There can be little doubt that the Cattle Egrets at Lake Alice came from the flourishing colonies around Lake Okeechobee, one of which contained over three hundred nests in the spring of 1954 (Sprunt, *in litt.*).

The adults of most species of birds, including herons, tend to occupy the same home range year after year, even if they are migratory, and use it only during the breeding season. Therefore I do not believe that random wandering can satisfactorily account for the establishment of new nesting colonies. Skead (1952: 210) holds a different opinion. In South Africa, wandering flocks of Cattle Egrets, the origins of which are obscure, may, he believes, found new colonies. There is no evidence of such wandering *flocks* in the Americas. Two alternative explanations of the dispersal will be considered: (1) Wandering immature Cattle Egrets could have settled in the area, or (2) adult Cattle Egrets could have mingled with flocks of other species of herons from Lake Alice and accompanied them to the breeding colony.

In most species of birds it is the young individuals without established home ranges which tend to wander and settle in unoccupied areas. Young herons hatched in the southern states regularly wander north during the late summer. A number of Cattle Egrets appeared in northern regions (Massachusetts, New Jersey, Virginia, Maryland, Illinois, Newfoundland) in the summers of 1952 and 1953 (Peterson, 1954). This would seem easily to account for the presence of the Cattle Egrets which nested at Lake Alice. But this explanation is untenable, as the evidence will show.

First, the exodus to the north takes place in late summer. The birds at Lake Alice arrived in the spring. I am certain, for reasons previously stated, that there were no Cattle Egrets in the Lake Alice and Payne's Prairie region in the summer and early autumn of 1953. Second, wandering immature herons return south in the autumn; they do not remain in the northern areas to nest. Third, the Cattle Egrets nested at Lake Alice their first year there. Cattle Egrets do not breed until the second season following hatching (Riddell, 1944: 507). Therefore at least five of the birds at Lake Alice were at least two years old and could not have arrived the previous summer as young of the year. We must therefore conclude that wandering immature birds were not the source of the Lake Alice colony.

The herons and ibises from Lake Alice winter in South Florida, where Cattle Egrets are already well established and fairly abundant. Since the interspecific flocking reaction is strong in the small herons,

the Cattle Egrets, once becoming associated with a flock of Snowy Egrets or other small herons from Lake Alice on their feeding and roosting grounds, would very likely remain with them during their northward migration to the Lake Alice colony.

All of my observations support these speculations. The Cattle Egrets arrived at Lake Alice in the spring at the same time as the other herons and ibises. Both at Lake Alice and in the Lake Okeechobee region, I have always found Cattle Egrets associating with flocks of the other small herons during the morning and evening flights. Around Lake Okeechobee I have seen both Cattle Egrets and Snowy Egrets feeding with the same herd of cattle.

The most logical conclusion is that the Cattle Egrets became mixed with the local herons on their wintering grounds and accompanied them to Lake Alice. In a similar manner they could have spread from South America to Florida, as many North American herons winter as far south as the Caribbean coast of South America, where Cattle Egrets are now quite common. They also could have spread from the Moluccas to Australia in the same way. However no herons migrate across the Atlantic, so their arrival in the New World from Africa was probably fortuitous, migrating birds having been driven off course by adverse weather. This is a common enough phenomenon, but one which results in the establishment of new colonies only under the most favorable conditions.

Establishment.—For successful establishment, the region must meet the ecological requirements of the species, and the initial colonizers must be able to maintain their numbers.

Cattle Egrets are apparently obligate commensals of large grazing mammals; I have seen hundreds of them around Lake Okeechobee but have never seen them feeding away from cattle. The recent growth of the cattle industry has made available to Cattle Egrets a vast new territory, because no large grazing mammals are indigenous to the New World tropics. In Florida, Snowy Egrets have recently developed a facultative feeding relationship with grazing cattle (Rice, 1954); observations which I plan to publish later indicate that they are ineffectual competitors of Cattle Egrets. Little Egrets, *Egretta garzetta* (Roberts, 1940: 21; Roosevelt, 1910: 467), and Lesser Egrets, *Mesophoyx intermedia* (Caldwell and Caldwell, 1931: 298), engage in a similar facultative symbiosis with large hoofed mammals within the Cattle Egrets' Old World range.

In colonial birds there exist numerical thresholds, below which the breeding cycle is not completed (Darling, 1938: 108). Fulmars (*Fulmarus glacialis*) can establish new breeding colonies only if a

certain minimum number of birds is present (Fisher and Waterston, 1941: 250). Many species of herons are highly gregarious, always nesting in large colonies. Cattle Egret colonies in South Africa contain from ten to two thousand nests, although it was not stated (Skead, 1952: 207) whether other species shared the colonies. I do not believe that Cattle Egrets would breed in colonies of fewer than ten pairs of birds.

There was an initial population of only seven Cattle Egrets at Lake Alice. If the above assumption is correct, they would not have nested if it had not been for the presence of the other species of herons. The latter apparently supplied the necessary stimulus to initiate the reproductive cycle, a stimulus ordinarily furnished by other members of the same species. Great Black-backed Gulls (*Larus marinus*) usually nest in colonies, but where other species of gulls are present, occasional pairs will nest in colonies of the latter (Darling, 1938: 57). This interspecific social facilitation could also explain the unusual success in South America of a very few Cattle Egrets arriving fortuitously from Africa.

Observations on Cattle Egrets suggest that mutual *inter*specific reactions to social stimuli have enabled this species to disperse to unoccupied areas with much greater facility than would have been possible otherwise. Furthermore, they have enabled the species to establish new breeding colonies with much smaller initial populations, thus overcoming the disadvantages of undercrowding which result from innate sociality, without giving up the ecological advantages of colonial nesting. This could conceivably give the species a slight, but perhaps critical, advantage over competing species when both are expanding into unoccupied range. Concomitant with this is a wide and often discontinuous geographical distribution with all its evolutionary potentialities.

SUMMARY

African Cattle Egrets (*Bubulcus ibis ibis*) became established in North Florida for the first time in the spring of 1954. At Lake Alice, Alachua County, an initial population of seven birds hatched three or four broods of young in a large heron and ibis colony. At least twelve Cattle Egrets were present at the close of the nesting season. In the spring of 1955 there were ten Cattle Egrets, including three breeding pairs, at the colony.

The initial seven Cattle Egrets doubtless came from Lake Okeechobee, 180 miles to the south. Observations suggest that they became associated with flocks of wintering herons from Lake Alice and ac-

companied them there. Emigration from South America to Florida, and from the Moluccas to Australia, possibly occurred in the same way. Summer wandering of juveniles is apparently an unimportant factor in this rapid "explosive" type of range expansion.

Range expansion was made possible by the cattle industry creating a suitable niche for the species.

It seems probable that so few Cattle Egrets could not have established a nesting colony at Lake Alice if it had not been for the presence of the other herons, which furnished sufficient stimulus to initiate the reproductive cycle.

The habit of associating with other species of herons would thus seem to be of survival value in facilitating dispersal and establishment.

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U. S. Fish and Wildlife Service, Building 45, Denver Federal Center, Denver 2, Colorado, February 14, 1955.

GENERAL NOTES

An Interesting Displacement Movement in a Slate-colored Junco.—I banded a male Slate-colored Junco (*Junco hyemalis*) May 4, 1951, putting the aluminum band on his right tarsus and a green one on his left.

Eleven days after his return in 1953, he was seen courting a female which had just arrived. Her behavior indicated plainly that her sexual drive had not yet reached high intensity. She faced him as he pursued her, showing him her breast, or hopped aside or away to evade his approach, thus displaying her urge to escape to the point of aggression.

The male pursued her doggedly with wings drooped and tail lifted. Every time when the female withstood him, he stooped and with great intensity pecked at the ground and *at his aluminum band* on the right tarsus.

Obviously, this pecking at the ground and at the aluminum band, both irrelevant actions in the present situation, were displacement activities, a "substitute behavior" (see Nice, Studies in the Life-history of the Song Sparrow. II, 1943, Trans. Linn. Soc. N. Y., 6: 156) as his sexual drive was denied by the female's condition of unreceptiveness.

In his article on "Derived" Activities; Their Causation, Biological Significance, Origin, and Emancipation during Evolution (Quarterly Rev. Biol. 1952, 27: 1: 17) Dr. Tinbergen arrives at the conclusion that, "So far as we know at present, displacement activities are always innate motor patterns, at least in fish, birds, and most mammals."

In the behavior of the junco male, however, there were two different displacement movements, pecking at the ground, a feeding movement that certainly is innate, and pecking at the band, a movement which is not innate. A curious detail is also that this particular bird, so far as I had observed, had not previously shown annoyance with the band after it was first placed on his leg, as is common with many newly banded individuals. The pecking of the band was therefore not an earlier established habit, but a displacement movement apparently derived from "the influence of external stimuli" (see Tinbergen, *op. cit.*, p. 19). It was learned, a purely acquired movement after the band was placed on its leg.

In 1954 and 1955, I observed the same male in identical situations. Every time he pecked the aluminum band, not the green one, when the female was unresponsive to his advances. In 1954, his display was of great intensity with wings drooped, tail spread wide and turning to show off the white outer rectrices, and all the feathers on back and rump erected, all of which showed a sexual urge strongly admixed with aggressiveness. This time his displacement pecking on the band was very vigorous and the pecking on the ground omitted.

Dr. Nice (*op. cit.*) relates how one of her hand-raised Song Sparrows, Y, tugged at strings when his drive to fight another one, A, was inhibited. In this case, however, captivity may have influenced the form of displacement movement taken, or the string may have appeared like dead grass or rootlets to the bird; in other words, the movement may have been innate.

Discussing the observation, Dr. Nice (*in litt.*) modified Dr. Tinbergen's conclusion by expressing the opinion that "most displacement activities are innate, but that some can be learned." It is well known that in man many learned displacement patterns occur and Tinbergen (*op. cit.*, p. 17) gave examples, "lighting a cigarette, fumbling with keys." Careful observation may reveal more examples of such acquired patterns in birds and other animals.—LOUISE DE KIRILINE LAWRENCE, *Rutherglen, Ontario, Canada.*

The Following Reaction in a Brood of Mute Swans.—On July 4, 1955, S. von Hofsten and I were observing a Mute Swan (*Cygnus olor*) and its brood of 3 cygnets about 3 or 4 days old at Ekebysjön, a few miles outside Stockholm, Sweden. For over half an hour we watched them and many other waterfowl from the north shore of the lake at a distance of about 200 feet. We then moved over to the other side at about the same distance from the swans.

After a while the parent, followed by the cygnets, swam away from the shelter of the reeds where they had been feeding. Arrived opposite the place where we stood, the swan suddenly rose and flew out of our sight to the western end of the lake some 1500 feet away, leaving the cygnets exposed and alone in the middle of the water.

At the disappearance of the parent, the cygnets at first swam around in confusion, giving loud "lost piping" notes. A minute later they bunched together, their "lost piping" gradually subsiding. Very soon we saw them in string formation paddling off in precisely the direction the adult swan had flown. They swam on and on, undismayed by the other waterfowl, unswerving in their course through tongues of lily-pads and sparse growth of reeds straight toward the west end of the lake.

To us it seemed impossible for the cygnets, floating low upon the water and with water-lilies and reeds intervening, to see their parent once it had alighted on the lake. Nor could we, from where we stood, hear either the parent or the young giving any calls.

The first three reactions of the cygnets upon being abandoned, their "lost piping," their confusion, and their bunching together, were common enough. This behavior pattern agrees with the findings of Drs. Tinbergen, Lorenz, Fabricius, and others, in their experimental work on ducks.

More remarkable was the orientation of these cygnets as they moved off on a determined course through rather formidable obstacles for such tiny swimmers towards a distant, presumably invisible, parent object. Obviously, they were driven by a high intensity motivation which was released by a visual stimulus no longer perceivable by the senses. We may also ask, was the impulse to follow present in only the leading cygnet, or to a higher degree in it than in the others? Or was the whole performance cooperative?

Fabricius and Boyd in "Experiments on the Following Reaction of Ducklings" (Wildfowl Trust Annual Report 1952–53) remark on the "complexity and variety of the interactions between different processes that make up even a simple behaviour pattern" and on the great variation of response in individuals "with similar histories," such as this brood of cygnets. It would seem, therefore, that nature may often provide the necessary relieving circumstances, as in this case, whereby apparently desperate situations in the wild can be successfully resolved.—Louise de Kiriline Lawrence, *Rutherglen, Ontario, Canada.*

Behavior of a Pratincole.—During the fall and winter of 1954 and the spring of 1955, I had an opportunity to observe some hostile behavior patterns in an Oriental Pratincole (*Glareola maldivarum* or *G. pratincola maldivarum*) at the New York Zoological Park.

This bird was kept in a small aviary, with many passerines (mostly estrildine finches) and a few larger birds (such as sandgrouse and quail).

Various disputes and fights were not uncommon in the aviary. The pratincole was remarkably sluggish when left alone; but it was vigorous in attempting to maintain an "individual distance" area around itself, within which it would not

willingly allow any other bird to approach. It was sometimes forced to escape before the larger birds; but it could usually induce the smaller trespassers to stop or retreat. This was accomplished by attacking the trespassers, by directing unmistakably hostile displays toward them, or by alternating attack intention movements and hostile displays in rapid succession.

One type of hostile display, particularly common in the spring, was a harsh, loud "chirrup" note, or a brief series of two or three similar "chirrup" notes. These sounds were usually accompanied by movements: the head was lifted and pointed slightly upward, and the neck was simultaneously stretched upward and forward. Such movements were variable, rapid, and almost always very brief.

A second type of hostile display, apparently threat (see Moynihan, Auk, 72: 247–259, 1955), was somewhat more elaborate and often more prolonged. It included a characteristic twittering call and one or two distinctive postures.

The twittering call itself was a rapid series of high-pitched, faint, rather melodious, monosyllabic notes (impossible to transcribe adequately). The number of notes varied from two or three to more than a dozen. This utterance was quite different, in quality, from any of the calls of the gulls, terns, and shorebirds with which I am familiar. In rhythm, however, it was slightly reminiscent of some staccato "long calls" and "crackling calls" of certain gulls (summarized in Moynihan, Behaviour, Supplement 4: 1–206, 1955), and also, probably, the "gakkering" call of the Sandwich Tern (described by van den Assem, De Levende Natuur, 57: 1–9, 1954).

The typical posture associated with twittering was assumed as soon as the call began. The bird stretched its head and neck downward and forward; and usually maintained this posture, while the call continued, until its opponent escaped or a fight developed.

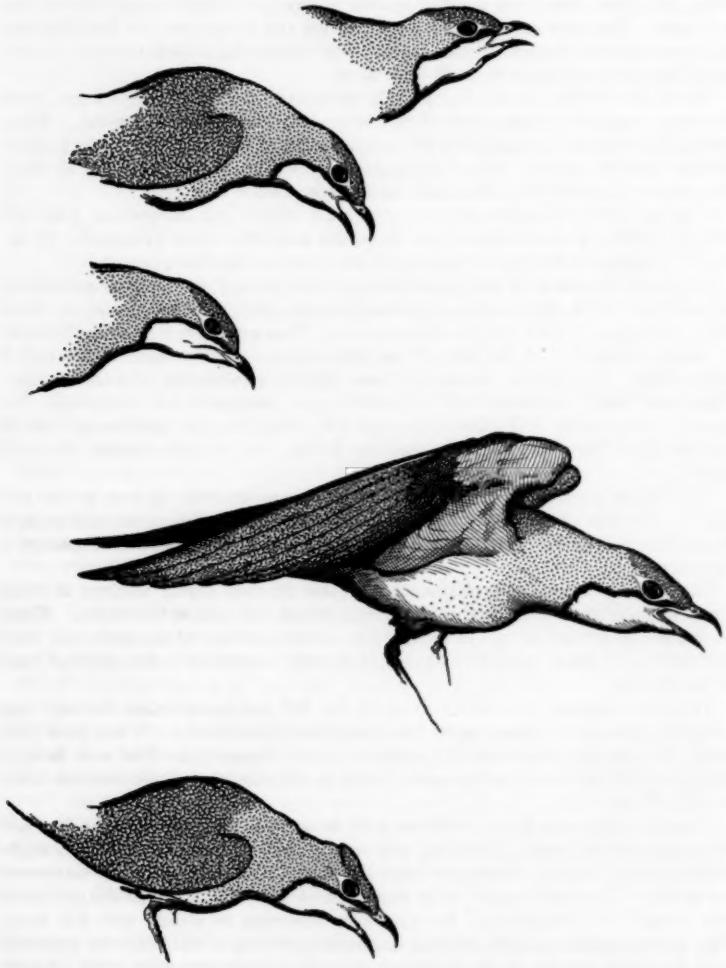
The motivation of this performance, like that of most threat displays in other birds, was obviously composed of conflicting attack and escape tendencies. These tendencies, or drives, seemed to fluctuate in relative and actual strength; and these fluctuations, in turn, seemed to be correlated with variations in the physical form of the display.

Thus, for instance, the extent to which the bill was opened and the neck was stretched seemed to depend upon the strength of both drives. When both were weak, the bill was closed and the neck was short (Figure C.). The neck became longer and the bill was opened more widely as the intensity of the two drives increased (Figure B.).

The head and neck were sometimes held in an approximately straight line; but this was relatively rare. The head was usually held at a slightly different angle, pointing more strongly downward than the neck. The most extensive downward inclination of the head seemed to be diagnostic of situations in which the pratincole was "timid" or "frightened," i.e. obviously reluctant to attack with full force. This would suggest that the extreme downward pointing of the head was produced by a relatively strong escape tendency, an escape drive somewhat more strongly activated than the attack drive.

The angle of the neck was usually rather stable. Occasionally, however, just before attacking, the bird would suddenly stretch its neck upward (Figure A.) and twitter more loudly. This would suggest that the upward movement occurred when the attack drive was much stronger than the escape drive.

A very conspicuous movement was sometimes superimposed upon the twittering posture. The bird would suddenly raise its arms, apparently without flexing or



POSTURES ASSOCIATED WITH THE TWITTERING CALL OF THE ORIENTAL PRATINCOLE. From top to bottom. A. Occasional posture before attack. B. Typical moderate-intensity posture. C. Typical low-intensity posture. D. High-intensity posture with wings raised. E. Moderate-intensity posture with "crest" raised.

rotating the carpi (Figure D.), and then as suddenly lower them again. This movement was most effective in revealing the rufous on the underside of the wing as a brilliant flash of color. It was so rarely performed that the causal factors responsible for its production were difficult to determine; but it seemed to appear when both types of hostile motivation were at their strongest possible (at their strongest, that is, in this particular environment).

Both the twittering postures and wing-movements can be easily explained as combinations of advance, retreat, and flying intention movements; movements which have become more or less thoroughly ritualized (i.e. have become standardized and acquired a function as social signals).

Another behavior pattern, sometimes superimposed upon the typical twittering posture, was more obscure in function and derivation. The bird would sometimes raise its crown feathers, slightly darker than the surrounding plumage, to form a definite, if not very conspicuous, crest (Figure E.). This was also accompanied, in some cases at least, by a slight raising or ruffling of the back and scapular feathers.

Such infrequent ruffling seemed to be a low-intensity indication of a more extreme behavior pattern usually produced after the completion of these hostile displays (both the "chirrup" and twittering). As soon as the pratincole had stopped displaying and relaxed its posture, it would ruffle all its head, neck, and body feathers, shake out its wings, and then smooth its whole plumage down again.

Ruffling and shaking are obviously "comfort movements" or derived from comfort movements; but their apparent standardization after hostile display might suggest that they may also subserve a social signal function, in a more natural environment, during intra-specific disputes.

The significance of any reaction by a caged bird, of course, is always difficult to analyze; and the hostile behavior patterns described in the preceding paragraphs may comprise no more than a small fraction of the total hostile behavior shown by Oriental Pratincoles in the wild. (Yeates [Brit. Birds, 41: 301–303, 1948], has described several apparently hostile patterns of the Common Pratincole [*G. p. pratincola*] breeding in the Camargue. Some of these patterns may be related to those described above; but the nature and extent of such possible relationships must remain indeterminate until further studies have been made.)

If, therefore, the hostile behavior patterns of this captive Oriental Pratincole have been discussed in some detail, it is only because they have a certain evolutionary interest. They resemble certain hostile displays of gulls and terns. The rhythm of the twittering call has already been mentioned in this connection, but the associated movements and postures are even more suggestive. Certain threat displays of the Laughing Gull and the Sandwich Tern include a ruffling component (Noble and Wurm, Ann. N. Y. Acad. Sci., 45: 179–220, 1943; van den Assem, *op. cit.*, 1954), and so do other displays in such species as the Franklin's Gull (personal observation). More important, the various twittering postures are quite similar in form to some of the "oblique," "low oblique," and "head-down" threat display postures that have been found in many different species of gulls and skuas (see Moynihan, Behaviour, Supplement 4: 1–206, 1955); and this captive pratincole assumed these postures and began twittering in situations very much like those in which many captive gulls would assume an "oblique," "low oblique," or "head-down" posture and begin the "long call."

This hostile behavior may thus provide further evidence of the close relationship between the families Glareolidae and Laridae within the order Charadriiformes.—M. Moynihan, *Department of Conservation, Cornell University, Ithaca, New York.*

Unusual Bird Records for Ohio.—The following observations were made at South Bass and Starve islands, which are part of the western Lake Erie archipelago. These islands are situated about four miles north of the Ohio mainland and are part of Ottawa County, Ohio. South Bass has an area of about 2.6 square miles and Starve an area of 0.6 of an acre. Both islands have much exposed limestone bedrock.

Branta bernicla hrota, American Brant.—At daybreak on November 7, 1950, while on Starve Island watching a huge southward movement of waterfowl I heard the honk of a goose and saw a Brant sitting upon the water. I later succeeded in collecting it, and it proved to be an adult male as indicated by the wing pattern, large penis, and lack of a bursa of Fabricius. It was rather thin, weighing 1040.0 grams. The belly feathers were very light colored, and the whitish area on each side of the neck rather small. The skin is No. 7940 in the Ohio State Museum. The only other extant Ohio specimen of which I am aware, is also in the Ohio State Museum and is labelled "Lake Erie, Nov. 10, 1874."

About 7:00 A.M. on May 1, 1955, while observing a mated pair of Mallards (*Anas platyrhynchos*), which were courting and feeding in the shallows near South Bass Island, I saw a Brant fly from adjacent Starve Island to alight with the Mallards and to begin feeding upon filamentous algae. This Brant had a very pale belly which contrasted sharply with the black breast; the short bill and whitish areas on the sides of the neck were plainly evident. I watched the bird for approximately an hour, sometimes at a distance of 60 feet. During this period it was inadvertently flushed six times by passing planes and boats. When flushed the last time, it and two Black Ducks (*Anas fulvigula*) flew southward together toward the mainland.

Histrionicus histrionicus, Harlequin Duck.—During a northwest blow on the early morning of November 2, 1951, I was in a boat about 100 feet from Starve Island watching the largest southward flight of waterfowl which I had witnessed about the islands in the last ten years. While identifying some of the ducks and geese as flocks of them flew past me in a continuous procession, I saw a small duck flying high in the air. When it was about to pass me, it turned abruptly and headed towards my boat. Recognizing it as a Harlequin Duck I collected it. The bird weighed 507.4 grams and was very thin; its alimentary tract was empty except for 15.0 grams of fine gravel in the gizzard. The condition of the tail feathers, large bursa of Fabricius, syrinx, testis, and rather undeveloped penis indicated that it was a juvenal male; its plumage was superficially similar to that of the female. The following description is given because of the scarcity of such descriptions of fall juvenals in the literature: Dorsal surface of upper mandible light blue except for the nail which was tipped with clear yellow; ventral surface of lower mandible pale blue except for the yellowish gular area; irises yellow-brown; tarsi bright greenish-yellow; dorsal surface of toes yellow and greenish-yellow except the joints which were dusky; dorsal webbing and entire ventral surface of foot and hind toe dusky. The skin is deposited as No. 7982 in the Ohio State Museum. Donald J. Borror (A check-list of the birds of Ohio. Ohio Journ. of Sci., 50: 10, 1950) placed this species in the hypothetical section because of a lack of a preserved specimen. There are a few published sight records.

Falco rusticolus, Gyrfalcon.—At approximately half an hour before sunset on November 26, 1951, while crossing a large field on the northern end of South Bass Island, I saw a large hawk approaching from the direction of Middle Bass Island. As the bird passed me about 200 feet away, it turned and circled once, giving me abundant opportunity to note its specific characteristics, which were those of a

Gyrfalcon. This bird differed from the Peregrine Falcon (*Falco peregrinus*) in its notably larger size, in the more triangularly-shaped wings, which seemingly were very broad at their bases, in the more uniform coloration, which was whitish and mottled with grays, not browns, in lacking the well-defined "moustachios" so characteristic of the Peregrine, and in the slower wing beat. The Gyrfalcon's coloration was markedly similar to that of the painting of *Falco rusticolus gyrfalco* on Plate 50 in E. H. Eaton's "Birds of New York" (1914, pt. 2. Albany). Its huge size was aptly demonstrated when, in flying towards Peach Point, the hawk pursued an adult American Herring Gull (*Larus argentatus smithsonianus*), the size of the latter appearing to be only slightly larger than that of the hawk.

An hour later Mr. Melvin Cover brought me a still-warm, limp Black Duck (*Anas fulvigula*) which he had found 15 minutes previously lying on the causeway at Peach Point, a neck of land separating Lake Erie from Terwilliger's Pond. The duck was a male weighing 1220 grams. An autopsy disclosed that a blow, delivered from above, had struck the duck in the middle of its back near the junction of the dorso-lumbar and sacral vertebrae, fracturing the fused vertebrae and driving two fractured portions into the kidneys, cutting some large blood vessels which produced an abdominal hemorrhage. I have examined over a dozen other birds immediately after falcons had killed them and have found similar fractures; I therefore conclude that the Black Duck had been struck by the closed feet of a falcon, presumably the Gyrfalcon which I had seen flying towards Peach Point.

I searched the fields and shores between November 27 and 30, finding a female Common Golden-eye (*Bucephala clangula*) and four female Ring-necked Pheasants (*Phasianus colchicus*) which had similarly broken vertebral columns and much of their flesh removed in a characteristic fashion by an avian predator. No Peregrine Falcons or large owls had been seen during the previous month, and it is highly possible that these birds were killed by the Gyrfalcon.

Borror (*op. cit.*: 3) notes three sight records for Ohio, which are published and mentions two specimens, collected in the state and preserved in museums.

Larus argentatus leucopterus, Greenland Herring Gull (formerly known as Iceland Gull).—During the latter part of February, 1946, several hundred fish shanties were located about a half of a mile west of South Bass Island on the ice-covered lake. Fishermen in these shanties threw their unwanted small fishes and discarded portions of larger ones upon the ice, this refuse attracting many gulls which fed upon it. While in my shanty on February 24 and while throwing food to individuals of four species of gulls in order to take notes upon their calls, I saw an immature Greenland Herring Gull alight among the feeding birds, remaining approximately two hours. This immature was only slightly larger than the five Ring-billed Gulls (*Larus delawarensis*) with which it associated and was definitely smaller than the six Glaucous Gulls (*Larus hyberboreus*) which were also present. Its plumage was very buffy and similar to the color of a Buff-breasted Sandpiper (*Tryngites subruficollis*); the basal third of its small bill (quite small when compared with the much larger bills of the Glaucous Gulls) was yellowish, the remainder black; its wings were more pointed than were those of the Glaucous Gulls and the wing beat more rapid; its voice was different from the voice of any other gull present. Excellent opportunities to closely observe this bird were had because whenever I placed a fish on the ice just outside of the shanty door the gull would approach and eat it. Borror (*op. cit.*: 11) has rightly placed this form in his hypothetical list because of lack of a specimen captured in Ohio.

Larus argentatus thayeri, Thayer's Herring Gull.—Parts of February 25 and 26,

1946, were spent in the above-mentioned fish shanty recording the call notes of the American Herring, Glaucous, Ring-billed, and Great Black-backed (*Larus marinus*) gulls. By February 26, I believed that I could recognize by voice alone any individuals of the above-mentioned four gull species. Then at noon I heard an unrecognized call and peering out of a shanty window I saw an immature gull whose plumage somewhat resembled that of an immature Glaucous Gull except that it was a darker brown; it was smaller in size than any of the three immature and three adult Glaucous Gulls present and was about the average size of a Herring Gull; its plumage was not as dusky as were those of the immature Herring Gulls. Greatly puzzled, I collected the bird. It was a very fat female weighing 1017 grams: its irises were brown flecked with golden; the tarsi were silvery-gray with some buffy. Its skin is No. 114,587 in the Museum of Zoology of the University of Michigan.

Because of a lack of comparable material at the museum, identification of this specimen remained in doubt until 1950 when Dr. C. O. Handley, Jr. compared it with specimens in the U. S. National Museum and discovered that it was an immature *thayeri*. This subspecies of the Herring Gull has not been previously recorded for Ohio.

Larus atricilla, Laughing Gull.—A climatic cold front moving in a southeasterly direction passed over South Bass Island about noon on September 12, 1953. By 3:00 P.M. the wind had increased in velocity to an average of 35 m.p.h. and gusted at over 45 m.p.h., and these winds forced more than 700 Herring and Ring-billed gulls to seek shelter about the lee of the island. While watching these gulls in the expectation of seeing a Franklin's Gull (*Larus pipixcan*), a species which sometimes is present at this season during a northwest blow, I saw a gull about the size of a Franklin's but with the dark breast and other characteristics of a Laughing Gull. This bird was flying shoreward toward a huge flock of gulls and disappeared among them. From its method of flight it appeared to be quite exhausted. Further efforts to relocate this bird were of no avail until the morning of September 14, when walking along the beach Professor and Mrs. John B. Titchener saw a solitary bird, sitting with its head tucked down as if it were asleep. But upon approaching closer they found it to be dead, apparently having died only a few minutes previously because its body was still limp and warm. They immediately brought the bird to me. Its skin is No. 8063 in the Ohio State Museum. The bird, a juvenal female, was extremely emaciated, weighing only 219.5 grams; its alimentary tract was empty except for an undigested, small crayfish and fragments of six Coleoptera which Professor Josef N. Knull identified as *Drasterius dorsalis* (Say). Its feet and bill were black.

Strix nebulosa nebulosa, Great Gray Owl.—At daylight on October 30, 1947, while nearing Starve Island in a boat, I saw a flock of about a dozen Herring Gulls circling above a large tree on the island and harassing a Great Gray Owl, which was perched on a limb of the tree near the trunk. This owl's plumage was predominantly dusky, not brownish as are the plumages of the Great Horned Owl (*Bubo virginianus virginianus*); the streakings on neck and upper breast were vertical, not barred as are Northern Barred Owls (*Strix varia varia*); the huge, globular-shaped head contained large facial disks; the irises were yellow; the tail appeared to be far longer in comparison to body length than are the tails of Horned, Barred, and Snowy (*Nyctea scandiaca*) owls and was almost twice the length of the tails of the Herring Gulls; and the ventral surface of the tail was barred and the distal end rounded. When I had approached to within 200 feet of the bird, it left the tree and flew past me, whereupon I was able to note that its round-tipped wings were much wider and

apparently somewhat longer than were the wings of the Herring Gulls and that there was a darkish area in their centers near the bases of the primaries on the underside of each wing. Borror (*op. cit.*: 11) has placed this species in his hypothetical list of Ohio birds because of a lack of a preserved specimen.

Corvus corax, Common Raven.—On the morning of January 20, 1946, while I was walking westward over the ice-covered lake from South Bass Island towards a colony of fish shanties, I observed for five minutes a Raven which was alternately soaring and flapping, and occasionally croaking, as it circled about the shanties. Comparisons were made between it and six Crows (*Corvus brachyrhynchos*) which were nearby. I again saw a Raven on February 16 and on March 6, and on each occasion the bird was flying from South Bass Island towards Middle Bass Island. On each of the three occasions the characteristics of this distinctive species were noted, and especially the wedge-shaped tail, soaring flight, and croaking voice. The Raven apparently was extirpated from Ohio as a permanent resident about 50 years ago.

Parus hudsonicus hudsonicus, Brown-capped Chickadee.—In a Red Cedar (*Juniperus virginianus*) woods on South Bass Island on November 19, 1951, Frank J. Ligas and I found a flock consisting of seven Black-capped Chickadees (*Parus atricapillus*) and two Brown-capped Chickadees. I collected and made skins of both of the latter. One of these, a female weighing 11.5 grams, is No. 130,037 in the Museum of Zoology of the University of Michigan; the other, a male weighing 11.9 grams, is No. 7983 in the Ohio State Museum. There were goodly flights of Black-caps through the western Lake Erie region that autumn.

In the same woods on December 6, 1954, Mary A. Trautman and I found a Brown-cap associating with a flock of ten Black-capped Chickadees. It was a male, weighing 10.9 grams, and is No. 9392 in the Ohio State Museum. A large flight of unprecedented size of Black-caps occurred during this autumn throughout the western Lake Erie Region.

Dr. Josselyn Van Tyne has identified the three Brown-caps as belonging to the subspecies *hudsonicus*.

Ammodramus bairdi, Baird's Sparrow.—Heavy rains fell about South Bass Island during the unseasonably warm (about 60° F.) night of April 21–22, 1951, preceding the arrival shortly before daybreak of an intense climatic cold front. At sunrise a dense fog prevailed which disappeared by 8:00 A.M., after which the temperature dropped rapidly, falling to slightly below 32° F. by mid-afternoon. As the fog began to dissipate there occurred the largest sparrow invasion which I have encountered on the island in more than a decade, and by 9:00 A.M. there were present thousands of Juncos (*Junco hyemalis*), hundreds of Savannah Sparrows (*Passerculus sandwichensis*), and many dozens each of Grasshopper (*Ammodramus savannarum*), Henslow's (*Passerherbulus henslowi*), Chipping (*Spizella passerina*), Field (*Spizella pusilla*), Fox (*Passerella iliaca*), Swamp (*Melospiza georgiana*), and Song (*Melospiza melodia*) sparrows. At the time I was particularly interested in obtaining information upon the relative abundance of the various subspecies of Savannah Sparrows occurring in the island region, so was examining with field glasses all individuals which I encountered. While looking over a large, mixed flock of Savannah, Henslow, and Field sparrows I found a Baird's Sparrow which I was able to observe carefully for periods of between 1 and 3 minutes upon six occasions. I failed to find the bird after making an unsuccessful attempt to collect it. This bird had a broad crown-stripe of rich ochraceous-buff and the remaining parts of the head and neck were suffused with yellow-ochre. A necklace crossed the breast in the form of a narrow

band, which was composed of a series of sharply-defined, short, blackish streaks; this band was conspicuously narrower than were the breast bands of the associating Savannah Sparrows. The bird *did not* have yellow before and/or above the eye or a yellowish or pale crown-stripe as have the Savannahs, or the olive-green suffusion about the sides of the head and hind-neck as have the Henslow's, or the red-brown speckled hind-neck as have the Leconte's Sparrows (*Passerherbulus caudacutus*), or the gray crown-stripe, nape, and earpatch, or buffy sides as have the Sharp-tailed Sparrows (*Ammospiza caudacuta*), all species which I have seen in life in Ohio and elsewhere as I have Baird's Sparrow in the West. I know of no published sight record for Baird's Sparrow in Ohio.—MILTON B. TRAUTMAN, *Natural Resources Institute, Ohio State University, Columbus 10, Ohio.*

Ten-Year Life History of a Banded Chimney Swift.—From a group of 99 Chimney Swifts (*Chaetura pelagica*) banded in 1944 on the campus of Kent State University at Kent, Ohio, one individual was observed each year for ten consecutive years. This bird, a female banded with No. 42-196907, outlived all of the others captured during the first season of this study, and its life history as reported here is the longest one known in detail of any Chimney Swift on record. Since she was first captured as an adult, she lived for at least 11 years.

This bird was banded on June 18, 1944. She was living in air shaft D4 with two other swifts. One was a male and the other a female. It is not certain which female was the mate and which was a visitor. (Nesting of Chimney Swifts in threesomes has been described in detail by Dexter, 1952b.) No.-07 had been observed incubating the eggs, although this is no proof of parentage since visitors are known to assist the parents with their nesting labors. At night one bird sat on the nest while the other two usually roosted just below it. Occasionally two birds sat on the nest, especially when the weather was cool. The nest was situated 12 feet down on the west wall and contained 4 eggs which had been laid between June 15 and 18. The three swifts remained together throughout the nesting period. Hatching began after July 5 and all four were hatched by the end of three days. Within a week all nestlings had blue pin feathers. During the third week of July they were fledged, and they had left the shaft by July 25. Five days later the parents and their seasonal visitor again roosted in D4 for the night with four juveniles. One or two of these may have been their own offspring, but at this time the birds were moving freely from place to place each night for roosting, and residence in a certain place did not necessarily indicate the home nesting site.

On April 28, 1945, a single Chimney Swift returned to shaft D4. Others joined it, and on June 6 another threesome was trapped there. No.-07 was back with the other female (42-196906), but a different male (42-196905) had taken the place of the previous one which did not return. No. -05 left his former mate (42-196904) in air shaft A1 where she then mated with another male. These three in D4 nested together for the season, but once again it is not certain if -07 was the functional female or a visitor with the other two. At times before and after nesting two often roosted side by side and the other one by itself a short distance away. At other times all three roosted together in a group. This year the threesome produced five eggs in a nest 34.4 feet down on the south wall. Because they nested so far down within the air shaft, the nesting could not be easily observed.

These same three returned to D4 in 1946. Nest building was under way by May 29. Again they built on the south wall, but nearly a foot lower -35.3 feet down from the top. Egg laying began June 10. I was absent for the remainder of the nesting season and consequently no further details are known. The companion female (-06) was the last swift trapped in 1946. It was alone in D4 on October 5.

In 1947 the same threesome returned to shaft D4. No. -07 was the first one back, arriving on May 3, but did not roost there every night at first. Two birds were observed together after May 12, and five days later -07 was retrapped with -06. These females were soon joined by the male -05. All three were captured together on June 3. No. -05 had earlier gone to shaft E6 with its mate of 1944 (42-196904). On June 4, nest building began, and the following day -06 left the threesome to mate with the male in C3 whose mate of the past three years nested in another shaft in 1947. (Since -06 left the group it would appear that -07 had been the functional female in this threesome during the preceding three years.) At the same time the male -05 also left D4 for a short time just as the nest was being completed. During his absence from D4 he mated with 42-196904 in shaft E6, but soon deserted her, and left her to build the nest alone, after some delay, and lay one egg before she abandoned the attempt. This pair had nested together in shaft A1 in 1944. The life history of -04 has already been published (Dexter, 1950). Male -05 then returned to -07 in D4, where she laid her first egg on June 16. Two days later the second egg appeared, and after intervals of two days the third and fourth eggs were laid. The nest was 36.2 feet down on the south wall. On July 13 three eggs had already hatched and within two days the fourth had hatched. By July 25 the juvenile plumage was complete. Observations were discontinued at that time.

On May 9, 1948, Nos. -06 and -07 were taken in D4, accompanied by male 42-188524. At first it appeared that females -06 and -07 would again be together and with the new male would form another threesome. However, -06 went back to C3 in a few days' time to her mate of the previous year. The male also left to mate with -04 in shaft E6. On May 30, -07 was found roosting with another female which left the next day. No. -07 remained alone, but on June 3, she abandoned D4 to join the male 42-188516 in B1. In three days they began nest construction, but the process was delayed and it was not completed until June 17. The first egg was laid on June 22. Two eggs were present on June 25, and three the following day. On July 12 the nest and eggs, placed only 6.6 feet from the top, were washed from the wall by a heavy rain and crashed to the bottom. A report on this accident with similar subsequent accidents which happened to this male and his various mates has been published in this journal (Dexter, 1952a). After a few days the mates abandoned their nesting site. On August 6, No. -07 was found roosting for the night in shaft E1 with nine other birds, one of which was the female (42-196909) which had nested there during the past five years. The life history of this bird and her mate has also been published (Dexter, 1951a, 1951b).

On April 28, 1949, No. -07 was captured in shaft B2 where she was alone. In three days she joined male No. 42-196941 in shaft G4. They began nest building on May 22 and completed it one week later. The nest was placed 13.4 feet from the top of the west wall. The first egg was laid on May 30. The second egg appeared four days later; the third and fourth appeared after intervals of two days. While one bird incubated the eggs, the other roosted just under the nest. Nestlings were first observed on June 26, and blue pin feathers appeared soon after. On July 2 the pin feathers began to open out, and in four days the nestlings were covered with black feathers. One week later two of them were out of the nest and clinging to the wall nearby. On July 14 all of them were out of the nest. Five days later three of them returned to the nest for a few days. In another four days time, however, they were all on the wing. At night, three to five birds were observed roosting in this shaft for two weeks, after which only one or two remained. Probably these were the parent birds. The nest fell from the wall on August 22.

On April 29, 1950, No. -07 was captured beside its mate of the previous season in shaft G4 where they had nested. Two nights later both roosted in shaft E6, but on opposite walls. They soon returned to G4, however, and began nest building on May 26. At various times a third bird was found roosting with them for the evening. The nest, 14 feet down on the west wall, was completed on June 2, and the first egg was laid the following day. Additional eggs appeared at intervals of two days until five had been laid. A third bird continued to visit them from time to time, and on June 10 it was captured and banded with No. 49-164539. The first egg hatched June 25. Three others hatched and one was lost. On July 8 the nest fell from the wall. One of the nestlings survived and was attended to at the bottom of the shaft by the parents until it could climb the wall. On July 25 it was able to fly out. The parents, however, remained there, and after nesting was completed in the colony they were visited by various birds roosting for the night. On September 1 there were seven together—the mates of G4 with a parent bird from A5, a juvenile from M7, and three unbanded juveniles. These soon scattered about, but on September 23, three swifts again roosted in G4—the present mate of -07, her mate of 1948 (42-188516), and another bird which was to become the mate of 42-188516 in 1952 and 1953.

No. -07 returned to G4 in 1951, but her mate of the past two years was never seen again. Another male, 42-188588, which had nested in G3 the previous year, joined No. -07 in G4 on May 4. They nested together on the west wall 13.5 feet down, producing the first egg on May 29, which was the first one to appear in this nesting colony. Three more were laid within a week, and as usual were not much incubated until the clutch was complete. Usually one parent remained on the eggs at night while the other roosted just below the nest. All four were safely raised, and on July 29 part of the nest fell away. In the night of July 30, nine swifts roosted here—No. -07 and her mate, a parent from A5, two non-breeding birds of the colony, a return which may have nested elsewhere, and three new juveniles. These birds then scattered. In the night of August 11, No. -07 and her mate roosted in shaft U1 on the next building with 41 other swifts.

Chimney Swifts returned to the campus in 1952 on April 20. That evening No. -07 was in shaft G4 by herself. Six days later she was joined by her former mate 42-188588. On May 10 they had a visitor, No. 48-166259, which may be one of their own offspring. The nest was completed at the same site as the previous year on May 27, and the first egg appeared three days later. Again, it was the first egg of the season in this colony. The next night they had two visitors, one of which was the same as before and the other another yearling (48-166261) which might also have been an offspring from this pair in G4. At intervals of two days, four more eggs were laid, but only four juvenile birds were produced. On July 20, No. -07 and her family were visited by a parent bird from A5, a visitor from E1, a non-breeding bird, and three juveniles.

In 1953, the behavior of No. -07 was erratic. While her mate of the past two years returned to G4, she did not, but was replaced by another female (one of the former visitors in G4 which previously nested in A5). No. -07 was first found that year on May 5 in shaft Q2 with a bird which had returned earlier to its former nesting site in R2. Later that bird went back to R2 for another nesting season, and in the meantime -07 moved into B1 with her former mate of 1948 (42-188516). However, they did not remain to nest with each other again. After staying alone in B1 for a few nights she disappeared until May 27 when she was found alone in shaft C1. Soon she was joined by another swift, and after June 3 they took up

TABLE 1

SUMMARY OF LIFE HISTORY OF FEMALE CHIMNEY SWIFT 42-196907 AT KENT, OHIO, 1944-1953

Year	*1944*	*1945*	*1946*	*1947*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
Date of first capture each year	June 18	June 6	May 7	May 3	May 9	April 28	April 29	May 4	April 20	May 5
Shaft used for nesting	D4	D4	D4	D4	B1 D4	G4	G4	G4	G4	C2 Q2
Shafts used for roosting	—	—	—	—	E1	B2	E6	U1	—	B1, C1
Mate	−08*	−05	−05	−05	−16	−41	−41	−88	−88	−95
Number nesting together	3	3	3	2	2	2	2	2	2	2
Regular visitor during nesting	−06?	−06?	−06?	—	—	—	—	—	—	—
Date nest building began	?	?	May 29	June 4	June 6	May 22	May 26	May 20	May 23	June 9
Wall used for nesting	West	South	South	South	North	West	West	West	West	West
Distance nest placed from top (in feet)	12	34.4	35.3	36.2	6.6	13.4	14	13.5	13.4	15.1
Date first egg laid	June 15	?	June 10	June 16	June 22	May 30	June 3	May 29	May 30	?
Number of eggs laid	4	5	?	4	3	4	5	4	5	?
Number of juveniles produced	4	4	?	4	0	4	1	4	4 −59	2
Occasional visitors during nesting	—	—	—	−06	—	—	39	—	−61	—

* Full band numbers are given in text.

residence in the adjacent air shaft, No. C2. Her mate proved to be 20-188695 which had been banded the previous year, but it is not certain whether or not he was a juvenile at that time. Upon his return in 1953 he was a visitor with the mates in D1 before pairing off with No. -07. They began nest building on June 9, at a time when most other swifts had their nests completed and some had already laid eggs. They produced two juveniles which left the nest, placed 15.1 feet down on the west wall, on August 2, and soon left the home shaft. The parents remained together there and continued to roost side by side at night. Between August 20 and 24 the nest fell from the wall and soon after that the male left. No. -07 continued to roost alone on the old nest site at nighttime. On August 30 she was seen for the last time. Table No. 1 summarizes the main events during the ten years of her known life history.

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Preservation of Birds' Nests with Plastic Spray.—During the course of collecting birds' nests for museums and private collections, we devised a highly satisfactory method of preserving and protecting them by applying several coats of a clear plastic spray from a pressurized container directly to the nests. Several such commercial preparations, sold under various trade names, have given complete satisfaction. The number of applications necessary to preserve the natural appearance of the nests depended on construction and nesting materials. For most medium-sized nests five coats were used. The plastic was applied at intervals of 10 to 15 minutes, allowing each coat to dry separately. Care was taken to saturate the interstices completely with the plastic. For best results, only thoroughly dried nests were sprayed; many plastic materials have a tendency to turn milky if used under conditions of high humidity. Insect pests were controlled with insecticides applied to the nests prior to the initial plastic coating. The nests usually were removed from their locations and dried, but some delicate types were coated *in situ* to avoid possible disturbances. The protection and flexibility of these plastic coatings prevented damage often associated with the handling and shipping of birds' nests.

Among the nests preserved with plastic sprays were: the flimsy, cup-shaped nests of the Puerto Rican Ground Dove (*Columbigallina passerina trochila*); the nests built of wild cotton (*Gossypium hirsutum*), by the Puerto Rican Emerald Humming Bird (*Chlorostilbon maugaeus*); and the curious nest-homes of the Puerto Rican Honey Creeper (*Coereba portoricensis portoricensis*). This method also was used to preserve a nest, woven of green moss and camouflaged with bits of bark, of the rare Puerto Rican Peewee (*Blacicus blancoi*).—J. L. SPENCER and W. C. KENNARD, *Federal Experiment Station, Mayaguez, Puerto Rico.*

Large Swainson's Hawk Flight in South Texas.—On October 6, 1953, I observed a large flight of hawks ten miles west of San Antonio, Texas. The flight came in the wake of a cold front, a norther, that had passed the night before. This norther had moved slowly south through the western half of Texas and seemed related to the hawk movement in San Antonio and other localities. As large hawk flights are seldom seen in central and south Texas in the fall, I made notes throughout the day as to size and shape of the flight, and then obtained data from other observers throughout Texas.

In San Antonio, on October 6, the weather was clear, following the rain that occurred as the cold front passed. The wind was from the north 15 to 30 miles per hour, diminishing during the day. The flight began at 8 A.M. with a few Swainson's Hawks (*Buteo swainsoni*) drifting down from the north. The southeastern part of the Edward's Plateau hill country is twenty miles to the north. By 9 A.M. the Swainson's Hawks were passing both as spiralling flocks and as many individual birds sailing directly south, the latter at the rate of 150 per minute. The number represents birds seen crossing Route 90, an east-to-west highway. For this counting, I did not use field glasses so the distance under observation ranges up to one-fourth mile to the west. Counts were made in eight two-minute periods, each period separated by three minutes. The birds per minute were computed from the counts (Figure 1).

From 8:45 to 9:45 A.M., big spiralling flocks of Swainson's were passing; these were counted separately from the single birds. The flocks ranged from 50 to 150 birds each, averaging 75. Four to six flocks passed per five-minute interval. Earlier, 8:00 to 8:45 A.M. smaller flocks were seen, averaging about 50 birds and occurring at an average of five per ten minutes. From 9:45 to 10:45, the flocks decreased in size to about 60 birds and from five to one flock per five minutes. After 10:45 A.M. only scattered flocks were seen so they were counted as individual birds.

The hawk species identified in flight included over 99 per cent Swainson's. This is similar to Allan D. Cruickshank's observations (Auk, 54: 385, 1937) of a large Swainson's Hawk flight October 2, 1936, in Hutchinson, Kansas. In the Texas flight a few of the Swainson's were in some form of melanistic plumage. The one per cent which was not Swainson's Hawks represented the following species listed in order of abundance: Red-tailed (*Buteo jamaicensis*) Sparrow, (*Falco sparverius*), Cooper's (*Accipiter cooperii*), Marsh (*Circus cyaneus*), Harlan's (*Buteo harlani*), and Sharp-shinned (*Accipiter striatus*). There were no Broad-winged Hawks (*Buteo platypterus*) although I had seen Broad-winged flights on the coast within a few weeks. Several observers determined all species with the aid of field glasses.

The shape of the flight was different from that in most descriptions. As in Cruickshank's flight, the birds moved directly south across gently rolling country and at an angle to the river valleys, the rivers of the area flowing to the southeast. But the flight had definite boundaries giving the effect of a channel of birds. The eastern boundary, from which I observed, was clearly defined; to the west were the counts reported, to the east scarcely one bird passed per five minutes. The vertical dimension of this channel was also of interest. The birds were found in a lower layer, from 50 to 500 feet above the ground and in a second layer at about 900 to 1500 feet above the ground. The width of the channel was measured along Route 90 on several occasions, once at 9 A.M. and several times toward the end of the flight, and found to be 4 miles wide plus or minus 0.1 mile. The western boundary was as sharply defined as the eastern, but the density appeared to diminish slightly toward the west.

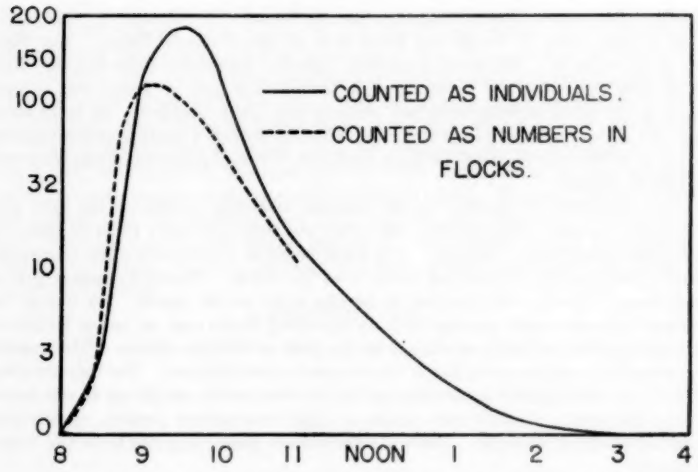

FIGURE 1. The number of hawks per minute seen crossing a quarter-mile section of Route 90 near San Antonio, Texas, October 6, 1953.

The count of individual birds added to those in flocks totals over 25,000 crossing the one-quarter-mile line under observation. This might indicate a total flight of several hundred thousand. One other flight of such size was reported by Griscom (Bull. Amer. Mus. Nat. Hist., 64: 155, 1932) where he says that most pass through Guatemala "in a few enormous flocks, which take hours to pass a given point." He mentions hearing of one flock "consisting of hundreds of thousands of birds" on October 25, 1925.

Reports from other observers indicated a general movement of hawks preceding the flight under discussion. About two weeks before the October 6 flight there was a large migration of Broad-winged Hawks in east and coastal Texas, reported by F. G. Watson and Luther C. Goldman, and several small flights of Swainson's from areas north of the Edward's Plateau. Around October 1, the Panhandle area reported small numbers of Swainson's, and Col. Wolfe and others reported big flights of several hundred Swainson's from the south east edges of the Edward's Plateau. Mrs. Jack Hagar at Rockport, Texas, 150 miles southeast of San Antonio, had large numbers of Swainson's from October 1 through October 7. These birds approached from a little east of north and left to the southwest. This might be considered an eastern part of the October 6 flight. On October 6, Mr. C. T. Gill reported 2000 Swainson's from Del Rio, a town 200 miles west of San Antonio. Possibly this was a western part of the flight.

It appears that the fall migration of Swainson's Hawks was moving south through central Texas around the first of October. A cold wave passed through on October 5. The following day, the birds, numbering possibly in the several hundreds of thousands, seemed to have assembled and passed south in a four-mile-wide channel. Two other parts of this migration are indicated by a flight of smaller size to the west and another flight east along the coast.—ROBERT P. FOX, *311 Beale Street, Wollaston 70, Massachusetts.*

Vultures as Disseminators of Anthrax.—In the article by Paul W. Parmalee on the vultures of Texas (Auk, 71; 1954) the following statement appears (pp. 447–448):—"Dubos (1948) states that bloodsucking flies, dogs, rats, coyotes, 'and particularly buzzards' should be barred from diseased animals (those with or dying from anthrax) since they 'probably' disseminate infectious materials, but published proof of this hypothesis in respect to vultures is wanting."

The following is a brief summary of a popular article published by Dr. Luis Schmidt Herman, founder and head of the Veterinary Supply House, Dr. L. Schmidt Herman y Cia. Ltda. of Santiago, Chile. The article appeared in a private publication of the company entitled "El Doctor" of April, 1942, under the title,—"Los Jotes, simbolo de Atraso, Infección y Mugre." (The Vultures, symbols of Backwardness, Infection, and Filth.)

Dr. Schmidt was called professionally to visit a large sheep farm in central Chile where it had been impossible to stop the constant loss of animals from Anthrax. In spite of the use of the best serums from France, Germany, the United States, Argentina, Australia, and Chile, the animals continued to die. Apparently it was impossible to immunize the stock so as to protect them from the disease.

A careful study of the situation on the spot revealed the fact that it was not customary to burn or even bury animals dying from infectious diseases. The vultures were allowed to dispose of them. These birds, both the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*) were there in sufficient numbers so that as soon as a sheep died it was only a question of minutes before the bones were nearly cleaned. The Black Vulture was by far the more abundant species. Vultures roosted by the hundred in eucalyptus groves in all the region the year round, and it was noticeable that the fields with eucalyptus groves where vultures roosted were those in which the most sheep died from anthrax.

After this preliminary study Dr. Schmidt told the administrator (the owner did not live on the farm) that unless something radical was done to eliminate the vultures, the Anthrax would continue and that the injections of serums, no matter how good they might be, would not stop the disease.

The administrator answered,—"Doctor, you know a lot, but the vultures do not cost me anything. Just imagine what it would cost me if I were obliged to burn or bury every sheep that died. On the other hand, I don't take much stock in all this talk about microbes and that they are as dangerous as you say. Why don't the vultures and the dogs die when they are eating dead animals every day? Haven't you seen the battles royal between the dogs and the vultures as to which shall have the larger share of the meat?"

"My dear sir," said Dr. Schmidt, "the owner of this farm has paid me to come here to his farm with a portable laboratory and everything necessary to make a careful study of the situation, find a solution if possible, and report my findings to him. What will you say if I can show you that vultures as well as dogs carry the microbes of anthrax in their intestines from animals which they eat?"

"If you can show me that, I will believe it," he answered. Dr. Schmidt's account continues. "My work was very simple. I shot half a dozen vultures and took excrement from them for my experiment. This was heated to 90 degrees centigrade for three minutes so as to destroy all the germs of the disease, but not the spores. The same proceedure was followed with excrement from several dogs that had been feeding on dead animals. Some of this cooked excrement was sown on different types of cultural media. The following day typical colonies of Anthrax microbes appeared. With some of this material I inoculated guinea pigs, rabbits, and one sheep. They all died with anthrax."

During all of this work Dr. Schmidt carefully explained each step to the administrator and his assistants, who gave careful attention to all the details, although they really understood very little of what was being done. Their frequent remarks to one another and the hilarious laughter which these frequently produced gave some idea of their opinion of the whole procedure. These also revealed their complete ignorance of the cause of Anthrax as well as their disdain for these "white collars from Santiago."

When the inoculated animals got sick their doubts began to vanish and when the last one died they were convinced. The sheep dying exactly as they had seen so many die almost daily caused the administrator to become almost panicky. He offered a peso apiece for vulture heads and started a regular campaign to kill every stray dog found in the pastures. The panic spread to the neighboring farms when they too, really understood that the vultures had been spreading the disease among their animals.—DILLMAN S. BULLOCK, *El Vergel, Angol, Chile.*

Red-wing Nesting in Bird House.—A large number of birds now often build their nests in bird houses or nest boxes provided by man, for example: bluebirds (*Sialia* species), Purple Martins (*Progne subis*), Tree Swallows (*Iridoprocne bicolor*), House Wrens (*Troglodytes aëdon*), Wood Ducks (*Aix sponsa*), and Golden-eyes (*Bucephala clangula*). These are all birds which otherwise nest in cavities in trees or other places. The House Sparrow (*Passer domesticus*), however, which frequently nests in bird houses, often builds nests in the open in trees or on other suitable supports, thus indicating its original habits. To my knowledge, however, the Red-wing (*Agelaius phoeniceus*) has not previously been reported to have nested in a bird house. A recent visitor to The Saskatchewan Museum of Natural History, Mr. A. E. Collett, of Regina, reported that in May, 1955, at Last Mountain Lake (Sask.) an adult male Red-wing was seen frequenting the platform of a wooden bird house, which had been set up the previous fall. A female Red-wing was observed carrying nest material into the box, and on May 24, eggs were seen in the box. Some time later in the month young Red-wings, which had evidently fledged from the nest in the box, were seen flying about in its vicinity. About June 28, another brood of Red-wings was heard in the box, and the male was still in attendance.

This bird house measured about 12 by 8 by 10 inches and had a flat red roof. The sides were painted green, and a 6-inch platform at the front had orange trim. The opening was about 3 inches square. The house was fastened to the top of a cedar post some 6 feet high, located about 15 feet from the edge of the water and about an equal distance from a cottage.

Supposedly the same male had previously held a territory in this area and had nested in the low vegetation at the edge of the water. The utilization of an artificial nest-site may perhaps be regarded as further evidence of the adaptability of the Red-wing. Its nests have been found on the ground as well as several feet up in trees, and in some areas the species nests commonly in alfalfa fields in upland habitat far from water. The possibility of Red-wings nesting in boxes had previously occurred to me owing mainly to an observation made of a closely related species in captivity. W. T. Page reported in 1906 for *Agelaius humeralis* (a South American blackbird): "Their one fault perhaps is an inordinate interest in the interiors of nesting receptacles." (*Bird Notes*, 5: 203–6.) Furthermore, part of the courtship behavior of the male Red-wing consists of crawling through dense clumps of vegetation, often followed by the female. The use of nest-boxes by Red-wings would provide an opportunity for detailed observations of nesting activities.—ROBERT W. NERO, *Saskatchewan Museum of Natural History, Regina, Saskatchewan, Canada.*

Breeding of the American Merganser in the Shenandoah Valley of Virginia.—Recent summer observations of the American Merganser (*Mergus merganser*) in the vicinity of Bridgewater, Rockingham County, Virginia, have been noted with sufficient frequency to warrant comment.

On May 30, 1953, I saw a female American Merganser with a brood of six half-grown young on Dry River, a rocky, moderately swift stream with occasional deep pools. The location was about a mile and three-quarters above the town of Bridgewater, near the village of Montezuma. The female and the entire brood swam rapidly down stream at my approach. Later on the same day a female, probably the same one, and an adult male were seen in flight over the river, one of the birds giving the rough, croaking quack typical of the species. The next day, May 31, adults and young were also observed in the same place by Mr. Max M. Carpenter.

I saw mergansers twice more in the summer of 1953. An adult female or young bird, was noted on Dry River about a half-mile above the first location on June 20. On July 18, a similar individual was seen on North River, half a mile above Bridgewater and about a mile and a half, air line, from the point of the first observation.

In conversation with Mr. A. S. Huffman of Bridgewater, a sportsman of long experience and with a good knowledge of waterfowl, I learned that in late June of 1947 he saw a female American Merganser with a brood of young on North River about two and one-half miles upstream from Bridgewater. I considered this to be a reliable record.

On July 6, 1954, I encountered a female American Merganser with a single downy duckling, certainly not over a few days out of the egg, on Dry River at Montezuma. The birds swam within fifteen feet of me.

Apparently there are no other published records of broods of the American Merganser in Virginia. Bent gives the nesting range of the species as "South formerly, and perhaps casually now, to the mountain regions of western Massachusetts, central Pennsylvania and in Ohio." (Bent, A. C., "Life Histories of North American Wild Fowl," Bull. U. S. N. M. No. 126: p. 12, 1923.) However, a nest and five young are reported from Chowan County, North Carolina. (Pearson, Brimley, and Brimley, "Birds of North Carolina," Raleigh, 1942, p. 84.)

The location at which the Virginia observations were made is in the center of the Shenandoah Valley. A bench mark of the U. S. Geodetic Survey, with an elevation given as 1220 feet above sea level, is located where Virginia Rt. 257 crosses Dry River at Montezuma.—HARRY G. M. JOPSON, *Department of Biology, Bridgewater College, Bridgewater, Virginia.*

Red-headed Woodpeckers (*Melanerpes erythrocephalus*) Feeding on Carolina Locusts.—During the last two weeks of August, 1954, I had an opportunity of observing the habits of Red-headed Woodpeckers in the vicinity of a beach on Lake Erie in the southwest corner of Dunn Township, Haldimand County, Ontario. A male bird was noticed first on a sunny afternoon. It was perched on a pole about twenty feet tall and would fly rapidly from this perch to snatch up insects passing over the beach and then swing back to its perch and devour its prey after snapping off the wings. The most conspicuous insects taken were adults of the Carolina locust (*Dissosteira carolina*). It was their habit on warm days to frequent the sandy beach and to make flights of a few yards from one spot to another in this area. The locusts would also hover in the air with rapidly beating wings or dance up and down in flight above a particular spot. This activity is considered to be involved in the courtship of the locusts (W. S. Blatchley, 1920, Orthoptera of northeastern America. Nature Publ. Co., Indianapolis). During this hovering flight the locusts were easily snapped up by the foraging woodpecker.

On top of a bluff which formed one border of the beach there was a disused gravelly road. It was a favorite resting place for the locusts. At each side of the road was a row of telephone and hydroelectric poles, and on warm days two or three Red-headed Woodpeckers could be seen perched on the posts. They would swoop down to snatch up the flying locusts and then return to their former perches or continue across the road to a post on the other side. In some cases a bird would follow a locust down to the ground and then carry it to a pole before devouring it.

The Red-headed Woodpecker's habit of foraging for flying insects is referred to by A. C. Bent (1939, Life histories of North American woodpeckers. U. S. Natl. Mus. Bull. 174), who records that young grasshoppers are eaten and that the woodpeckers make flights from perches to capture insects.—W. W. JUDD, *Department of Zoology, University of Western Ontario, London, Ontario, Canada.*

Robin (*Turdus migratorius*) Feeding on Ocean Beach.—A Robin, apparently an adult female, was observed feeding on the sand beach near the edge of the ocean near the Quogue Beach Club, Quogue, Long Island, New York, on July 26, 27, and 28, 1954. The bird was chiefly following the line of marine algae washed up on the sand by the waves, which contained an unusually large amount of such material on those days, and was evidently feeding on small organisms in the weeds. The Robin fed close to small flocks of Sanderling (*Crocethia alba*) along the water's edge and came as near as three yards to the wash of the waves.

In some forty years of observing birds on the beaches of eastern Long Island, I had never before seen a Robin feeding on the beach in this way. This bird was seen to fly to a line of pines back of the dunes, near the lawn of a house. I suggest that the severe drought of that July dried up the Robin's usual sources of food and drove it to feed on the beach. Following a hard rain-storm on the night of July 28, the bird was no longer observed on the beach.

On July 20, 1955, a Robin was again observed feeding in the same manner at the Quogue Beach Club, and it is interesting to note that the weather had been very dry during the preceding few days.—WALDEN PELL, II, *St. Andrew's School, Middletown, Delaware.*

A Cowbird Incident.—On May 21, 1954, while setting out tomato plants in my garden, I noticed a male Cowbird (*Molothrus ater*) on the ground at the edge of the garden plot. Soon he was joined by a female; and the two were joined by another female as they moved along toward the north. The three went into the long grass bordering the garden and seemed to be searching for something. As I knew of a Song Sparrow's nest, well concealed in the grass only a few yards farther north, I watched closely.

Suddenly one of the female Cowbirds made a run and a lunge for the hidden nest, seemed to strike its contents, and, as I started forward, flew off carrying a very young nestling in her bill. All three flew off together.

The three callow young Song Sparrows that remained (eyes not yet open) were packed together in a small pocket of the grass about eight inches from the empty nest. One of them was bloody about the head but apparently not disabled. I replaced them in their nest, and for a few days they were cared for by their parents; but on May 25 the nest was empty.

It would seem probable that the original brood of four tiny nestlings, perhaps tangled together in the small nest, had been displaced en masse by the Cowbird in the moment before one of them was securely grasped by her bill.—A. D. DU BOIS, *Christmas Lake Road, Excelsior, Minnesota.*

Baldpate (*Mareca americana*) Nesting in Minnesota.—Dr. T. S. Roberts in the discussion of the Baldpate in his *Birds of Minnesota* states (page 233), "We have no record of the finding of a nest in Minnesota, but its occasional occurrence in pairs in the late spring and early summer suggests that probably it does breed rarely in the State."

Each spring numerous breeding pairs of Baldpates are seen on the Mud Lake National Wildlife Refuge near Holt, Minnesota. Brood counts for the past several years indicate considerable nesting in the extensive marshes; however, no nests have been found there to date.

A few pairs of Baldpates are seen on the Rice Lake National Wildlife Refuge, East Lake, Minnesota, each nesting season, and two broods were observed in 1947 by former Manager Karl Kobes. On June 30, 1939, P. Knopp and R. L. Coppess, formerly of the Fish and Wildlife Service, saw a brood of ten. While making a nesting survey of a small island in Rice Lake on June 2, 1949, John Wege and I flushed a female Baldpate from a clutch of 10 eggs. Photos of the nest and eggs were taken during a return trip on June 5. On June 20, the female was still incubating, and slow-motion movies (in color) were taken of her flushing from the nest.

The island, which is less than two acres in area, is covered with a heavy growth of raspberries, nettles, grasses, and other herbaceous growth, and includes one small low area of cattails and sedges. Wild grapes are plentiful, and the vines climb into the small aspen trees which are scattered thinly over the area. Several large basswood trees on the east and south sides of the island furnish a nesting site for a colony of herons and Double-crested Cormorants.

The nest was situated under an old log, the end of which was about 20 inches off the ground. Owing to the heavy herbaceous growth and the presence of the log, it was very well concealed. The nest had been constructed about five steps from the water's edge along the west shore of the island. It was lined with a good supply of down, which protruded up and partially over the eggs on the edge of the clutch. The female apparently made no effort to cover the eggs before flushing.

A visit to the nest on July 13 revealed that 8 of the 10 eggs had hatched. One of the remaining eggs was addled, and the other contained a fully developed embryo, which had failed to hatch. These two eggs measured 1.44×2.09 and 1.45×2.10 inches. On this same day a brood of five downy Baldpates was observed about one-half mile north of the island. One of these was caught and examined closely as the female feigned injury near our boat.

On July 24, 1949, two broods of Baldpates were seen on Rice Lake. One female was accompanied by five downy young, apparently only a few days of age. One of these young was captured and the female observed very close at hand as she gave the typical protesting performance. The other brood, also five young, seen on the same date were nearly half grown and could skitter and dive with agility. The female was positively identified as she feigned injury near our boat. Both these broods were seen in rather open stands of bulrush within 300 yards of the shoreline.

One other brood of Baldpates was seen during the summer of 1949 on the Rice Lake National Wildlife Refuge. This brood of seven young, about half grown, was seen on Mandy Lake (Little Rice Lake) on July 2.—FRANK R. MARTIN, *Upper Souris National Wildlife Refuge, Foxholm, North Dakota.*

Unusual Behavior of a Golden Eagle in Southeastern New Mexico.—On January 29, 1954, when making an aerial census of antelope in eastern Chaves County, New Mexico, I observed an incident which may be of interest to students of bird behavior. While a count was being made from an elevation of 200 feet of a herd of 58 antelope, a Golden Eagle was noted flying parallel with, and about 300

yards from, our Piper Super Cub. In order to facilitate a count of mature bucks, the pilot dove the plane to a point about 100 yards from the side of the running herd and leveled off 25 feet above the ground. The eagle simultaneously duplicated this maneuver except that he leveled off 25 feet from the antelope, almost disappearing into the large dust cloud above them. The eagle was seen to disappear and reappear several times, apparently having no difficulty moving in and out of the herd, now running at full speed and almost in single file. On one occasion the eagle dropped back to hover above a large mature buck bringing up the rear. During the five minutes of observation the eagle was not seen to strike an antelope. When last noted, the bird was still in pursuit of the running herd.—ALLEN E. ANDERSON, *New Mexico Game and Fish Department, Santa Fe, New Mexico* (*Contribution from P-R Project W-75-R-1*).

Marsh Hawk Pursues Domestic Cat.—On June 4, 1955, I was observing Short-eared Owls (*Asio flammeus*) and Marsh Hawks (*Circus cyaneus*) on a marsh in southwestern Waukesha County, Wisconsin. At about an hour after sunrise an adult male of the latter species was seen pursuing a common house cat through a field adjacent to the marsh.

The hawk flew several feet behind and about 10 feet above the cat which was running about as fast as possible towards the protective cover of a fencerow. The field through which the cat was running had a rather uniform cover depth of about 10 to 12 inches. During the chase the hawk dived three times to within one foot of the cat. It appeared to have no intention of actually striking it, however. When the cat entered the deeper cover along the fence the hawk hovered momentarily and then perched on a fence post about 10 feet from where the cat disappeared. It remained on the post for about 10 minutes before resuming its coursing over the fields. The cat was a medium-sized individual and was predominantly white but with some brown areas on the foreparts.

Although this was probably defensive behavior this same male Marsh Hawk consistently tolerated another male in its territory. This second male was mated to a female which was incubating about a third of a mile away, but no mate to the first bird was seen even after seven hours of observation during two successive mornings.—DANIEL D. BERGER, *510 E. MacArthur Road, Milwaukee 17, Wisconsin.*

Tree Sparrows (*Spizella arborea*) Feeding on the Common Reed.—On December 26, 1954, while making some observations in Pelham Bay Park, Bronx County, New York, I visited an area known as the Baychester marshes. These marshes support a luxuriant dense growth of Common Reed (*Phragmites communis* var. *Berlandieri*).

This plant is sometimes characterized as an indifferent halophyte which grows best in slightly basic or alkaline soils which are occasionally flooded with polluted tidal water (Eaton, Rhodora, 54: 135–137, 1952). In this case, the waters flooding the area came from adjacent Eastchester Creek.

In this type of habitat, I was attracted to a small flock of sparrows, consisting mainly of wintering Tree Sparrows. The birds were seen feeding in and among the large terminal panicles of the Common Reed. I then proceeded to examine these plants, but neither insects nor larval masses could be found. I can only conclude that the Tree Sparrows were either feeding on the seeds or other parts of the dried inflorescences.

This was the first observation I have ever made of any bird species feeding on this relatively poor source of food.—MAURICE L. RUSSAK, *1675 Metropolitan Avenue, New York 62, N. Y.*

Relation of the Tail Length of Cock Ring-necked Pheasants to Harem Size.—During the winter of 1953–1954, Donald Reid, a graduate student in the Department of Fisheries and Wildlife, Michigan State College, trapped 29 cock pheasants and marked them by cutting off their tails and placing a colored plastic band around the neck of each. This was done on the Michigan State College Farm, East Lansing, as part of a study of winter movements away from concentration points. The following spring between April 12 and May 21, it was noted that a marked difference existed between the numbers of hens seen with marked and unmarked cocks. During this period, individual marked cocks were observed 41 times. Three times a hen was with the cock; the other times the cock was alone. Individual unmarked cocks were observed 241 times. On 130 of these occasions, the cock was alone, 36 times one hen was present, 28 times there were two hens, 18 times three, 16 times four, 5 times five, 3 times six, once eight, and once nine hens were present. The differences between individual marked and unmarked cocks both with respect to the number seen alone and to harem size are highly significant statistically ($P < 0.001$). Observations of two or more cocks together were not included in these tabulations.

At the time the spring observations were made, in only 17 of the 41 observations of marked cocks was a colored neck band seen. Sixteen of the 17 with both neck band and bobbed tail and 22 of the 24 with only the bobbed tail were without hens. This difference was not significant and suggests that presence of a neck band probably had no effect on the ability of cocks to attract hens.

Following the logic of Tinbergen (Wilson Bull., **60**: 6–51, 1948) the long tail of the male may be a sign stimulus which acts as a visual releaser to evoke the attentiveness of hens. This seems plausible when it is realized that the courtship display of the cock pheasant involves the spreading of the tail while moving before the hen. This may be similiar to the situation described by Tinbergen in sticklebacks (*Gasterosteus aculeatus*). He observed that females of this fish were attracted to models of males with red abdomens but showed no interest in identical models in which the abdomens were not red.

There are two factors operating on the study area which may have tended to accentuate the disadvantage at which tailless cocks were placed. First, in this unhunted population, the sex ratio was about even. There was 1 cock per 1.05 hens in April and May based on 651 observations. Second, judging from roadside counts and counts of crowing cocks made in connection with other studies, the population density was high compared with most Michigan areas. Under the highly competitive conditions of an equal sex ratio and high populations, it seems possible that the lack of a tail might result in a more pronounced courtship disadvantage than under the more common circumstances of distorted sex ratios and lower population densities.—Aelred D. Geis and Lucien H. Elbert, *Zoology Department, Michigan State University, East Lansing, Michigan.*

Eastern Meadowlark (*Sturnella magna*) Eating a Traffic-killed Bird.—The note by Paul A. Stewart (Auk, 72: 83–84, 1955), about a captive Tufted Titmouse (*Parus bicolor*) feeding on the carcass of one of its own species, recalled to me a similar observation I made on a wild meadowlark near Bath, New York, on July 5, 1939.

A freshly-killed meadowlark, partly smashed by automobile traffic, lay near the edge of a well-traveled concrete highway. As I neared the spot in my car, I saw a bird tugging at the carcass. It was an Eastern Meadowlark, and as I stopped to watch, I clearly saw this bird pull off and eat bits of flesh from the dead bird.

Common Grackles (*Quiscalus quiscula*) have several times killed and eaten the brains and flesh of English Sparrows (*Passer domesticus*) that came too near the grackles at the birdbaths and feeders in my backyard bird sanctuary on Long Island. Other observers have reported this same phenomenon (i.e. Poor, Proc. Linn. Soc. N. Y., 54–57: 54–55, 1946, and Mayfield, Wilson Bull., 66: 271, 1954).

R. M. Lockley in his book, "I Know an Island," p. 182, 1939, told an unusual food-habits story of a Water Rail (*Rallus aquaticus*), a European bird that resembles our North American Virginia Rail (*Rallus limicola*). A bird-bander trapped, "ringed," and then released the Water Rail in a garden aviary on Shetland Island, north of Scotland, in Great Britain. The Water Rail, which was thought to be wholly insectivorous, devoured a quail in the enclosure the first night, and on the next day ate a Snow Bunting and a Green Finch "picking out the meat and leaving the skins and bones clean."

The Water Rail and our Common Grackle are examples of insect-eating birds that may at times be predatory on other birds. The Chuck-will's-widow (*Caprimulgus carolinensis*) is another highly insectivorous species that food-habits research has shown to be a seasonal if not regular eater of small birds. However, the behavior of the Meadowlark, in eating the flesh of one of its own kind, was scavenger-feeding, not predatory.

These records suggest that birds which we little suspect of meat-eating tendencies may be easily induced to eat meat, if it is available to them. I have fed and cared for (both adult and young) swallows, nuthatches, robins, catbirds, bluebirds, warblers, and other ill or injured songbirds until they were able to shift for themselves. All of them ate raw ground hamburger and canned dogfood. Red meat is rich in protein, and, at least temporarily, is a strengthening and satisfying substitute for the natural foods of insectivorous species. Zoo keepers use ground meat, preferably raw beef, in the diets of practically all insectivorous birds. I see no reason why almost any wild songbird might not be inclined to eat meat if it had the opportunity. —JOHN K. TERRES, *National Audubon Society, 1130 Fifth Avenue, New York 28, New York.*

Mourning Dove and Dickcissel on the Atlantic Ocean.—I crossed the Atlantic Ocean on the "African Dawn," which sailed from New York for the Azores on November 1, 1954. Shortly after sailing, a low pressure area moved up the coast, reaching New York about November 3 and continuing on towards Nova Scotia. During the day and night of November 3, winds reached gale force. At 3:00 P.M. on November 4, a Mourning Dove (*Zenaidura macroura*) alighted on the ship. At that time, our position was 39° 45′ N., 57° 47′ W. During the remainder of the afternoon, it made short flights over the water but always returned, and stayed most of the time on deck. It spent the night on board and took off from the ship at 8:00 the following morning.

An hour later (November 5, at 9:00 A.M.) a Dickcissel (*Spiza americana*) flew on board. It appeared much more exhausted than the Mourning Dove had been and spent most of the morning hiding about the rigging, although it made occasional short flights. At 12:30 P.M., while flying close to the ship, it fell into the waves. The noon position of the vessel was 39° 33′ N., 49° 58′ W. This point is approximately 1,116 nautical miles from New York.

It seems probable that both of these birds were caught by the storm during migration. The Mourning Dove has been recorded on several occasions from the Bermudas.—DONALD W. LAMM, *American Consulate General, Accra, Gold Coast.*

Masked Duck and Jacana at Brownsville, Texas.—Though known from the lower Rio Grande Valley of Texas since 1891 and 1876, respectively, the Masked Duck (*Oxyura dominica*) and Jacana (*Jacana spinosa*) have been recorded so infrequently in the United States that the following observations seem noteworthy.

On September 4, 1937, in a reed-choked resaca within a mile of Brownsville, I had protracted views of eight Masked Ducks—a flock of seven, including one adult male, and another adult male some little distance apart. Because of the many years which have elapsed, I prefer to quote directly from my field notes, although most of the details are still vividly remembered.

"The Masked Ducks were very shy, particularly the two adult males which never strayed far from the reeds. The females [presumably including young of both sexes] kept close together, and while they showed uneasiness as I waded knee-deep into their haunts, they did not take alarm, but slowly swam off through the marsh vegetation. At one time they all loitered in an unprotected spot where I had excellent views of their small chunky bodies and the two very conspicuous black streaks on each side of their heads. The males looked very much like Ruddies [*Oxyura jamaicensis*] in nuptial plumage but were noticeably smaller and, lacking white cheeks, had a black mask on the top, front, and sides of head. Their tails looked even longer and spinier than a Ruddy's. The males' bills were bright blue. I never saw them fly, nor in any way exhibit the white wing-patch. These ducks can float with just the head and upper neck above the water, like a grebe. Silent."

Returning to the same resaca two days later, when an adult male and four in female plumage were closely approached in ideal light, I finally saw a reddish male and two of the other ducks stretch their wings sufficiently to show the large, clearly marked, white patch on the secondaries.

In mid-March 1939, near Isla in southern Veracruz, México, I had further opportunity to observe Masked Ducks under much the same circumstances, with the added feature of seeing two males in flight.

Another unexpected bird, September 4, 1937, at the very resaca near Brownsville where the Masked Ducks were skulking, was an adult Jacana (*Jacana spinosa*). It was watched for several minutes walking on matted marsh vegetation and along the water's edge. When I approached closely enough to see its fantastically long toes, it spread its yellow-patterned wings, and uttering an explosive *kip*, familiar to me from many previous encounters with this species in the tropics, flew weakly, and with long legs extended, to the other side of the resaca. Even from that distance its yellow frontal shield and chestnut and black body were unmistakable.—FREDERICK W. LOETSCHER, JR., *Centre College, Danville, Kentucky.*

Masked Duck in Florida.—'Florida Bird Life,' as recently revised by Alexander Sprunt, Jr., does not list the Masked Duck (*Oxyura dominica*). On April 13, 1955, a small brown duck was brought to my home in Key West by a neighbor, who found it lying dead in the street one morning (about March 30). She had reported it to the City Sanitary Department, but they failed to pick it up. She then carried it to her back yard, where it remained for two weeks. All flesh had been destroyed by ants, but the feathers were in fairly good condition. I believed it to be of the above species and forwarded the specimen to Dr. H. M. Stevenson, Department of Zoology, Florida State University, who verified the identification. The specimen is now a part of the skin collection at that institution.—FRANCES HAMES, *1230 von Phister St., Key West, Florida.*

REVIEWS

The Passenger Pigeon, its Natural History and Extinction.—A. W. Schorger. (Madison, the University of Wisconsin Press). 424 pp. with 22 figures and 5 tables. Feb. 18, 1955. Price $7.50.—This book is as notable, painstaking, and laborious a piece of scholarship as the reviewer has seen in many years. Not only does the bibliography contain over 2200 titles, but a thorough search has also been made of early newspapers in Wisconsin, Minnesota, western New York, and doubtless elsewhere, which would raise the number to about 10,000 items. The bibliography in the book alone is 103 printed pages, most ingeniously arranged. Each chapter has a series of numbered notes to references, and to make using easier, there is a running head on every page reading "Notes on pages so and so," making it unnecessary to remember the pages of the various chapters.

The object is to come as near as possible to recreating the various phases of the life history of this extinct bird as can be done, since no early ornithologist ever attempted to do it in time, most of the early writing being on hearsay evidence from hunters and trappers. Once one of the most abundant birds on earth, its sudden disappearance confounded all the experts, and the effort to save it came 20 years too late. As the writer so well says in the preface, "It is not an easy task to reconstruct the life history of an extinct species in the face of a large and contradictory literature since much is beyond absolute proof."

This quotation is the key to the objective analysis which is the outstanding feature of the book. Mr. Schorger by no means swallows everything whole, uses a real gift for sifting and reasoning, rejects many statements as unsatisfactory, and reaches certain conclusions with which some people might not agree. It is no fault of his if some of the evidence is incomplete or unsatisfactory, and hence open to varied interpretation. In some cases he does not believe or doubts his own quotation.

The text is divided into a total of 16 chapters, on a more or less routine order of topics, which call for little comment here. Chapter I (early accounts) begins with early March (1534) and is as widely selected geographically as possible. It closes with some real "curiosa," where great flights of pigeons were portents of epidemics or disaster. The chapters on description, anatomy, nomenclature, and distribution (notably thorough) are more or less routine. The one on migration is invaluable as it brings together in one place, every reliable date of record, both spring and fall, ever published. Another chapter on late records is highly critical, casts doubt on some, and quietly discards many already published on the ground that the data were unsatisfactory or inconclusive. As might readily be expected, sight records do not fare very well. A highly original chapter is on the evaluation of illustrations, and our author finds relatively few entirely satisfactory.

An ideal chapter to discuss is the one on food, which includes such subheadings as methods of feeding, plant foods, animal foods, mineral substances, and effect on agriculture. The number of separate items or facts brought out is truly remarkable, many of them still doubtful, improbable or highly controversial. Beech mast in the North and acorns in the South were vitally important, and Mr. Schorger gives records to show how irregular great years of beech mast were in both New York and Michigan, usually on alternate years, odd in New York and even in Michigan. It is possible that we have here one of the primal causes of the irregularity of large pigeon nesting, though it is now too late to prove it by any definite or direct correlation. It was assumed that large nestings in Wisconsin required a great crop of acorns of oaks of known species. Our author also shows the importance of earthworms and salt in the nesting seasons, but perhaps overlooked the fact that in the

Northeastern States, there were no native earthworms, all were recently introduced from Europe. We have the same mystery here as with the Woodcock. Long billed as "food primarily earthworms," what was it in the days of its former abundance in New England prior to 1700?

I have deliberately left the to me most interesting and controversial chapter to the last, Chapter 9 on decrease and extinction, with sub-headings population figures, decrease, enemies, extinction, conservation, and legislation. Our author distrusts all estimates of the enormous size of most of the flocks. In some cases he shows that the arithmetic was incorrect, and all figures are based on the premise that the great flocks flew at an average speed of 60 miles per hour, which cannot be proved. Nor is there now any way of finding out how many pigeons occupied a cubic yard of space. Mr. Schorger adopts a most ingenious method, the total number of acres of principal range; allowing 5–6 birds per acre, we *might* get a total population of 3–5 billion birds. The author has already pointed out that Nuttall's idea was incorrect, that the entire population was in one great flock. The problem of the numbers in one great flock is unimportant, as there is no answer to the rhetorical question, how large were the other great flocks and where were they?

Mr. Schorger immediately raises the questions, how were such enormous numbers attained and maintained when it laid but one egg. He cites other species still existing in great numbers with similar low reproductive capacity.

The reviewer has long thought himself moderately familiar with the literature on pigeons in the northeastern States. Schorger's first critical comment on decrease stopped me cold. It was alleged "long before the colonists could have had a noticeable effect on their numbers." This brings out the extreme irregularity of pigeon flights in earlier days, owing possibly to fluctuating food supply, cold weather in the South, and later the cutting of primeval forests. This involved the rereading of the entire book twice to search for additional lines of evidence, and by no means in vain.

We now approach the topic of final extinction. Mr. Schorger's mounting evidence shows that in the Northeast there was a marked decline in the latter part of the 18th century. It became precipitous from 1871–1880, and the bird's eventual extinction was foreseen at that time, although an optimistic note was struck in 1889. This presupposed adequate protection laws which were not forthcoming. Every cause except overshooting was invoked, and Mr. Schorger deals shortly but fairly with all of them. They are mass drowning, fire, poison, disease. More plausible were the cutting of the great forests, the lack of beech mast and acorns in adequate quantity, lack of sex rhythm in a bird requiring mass association and colonial nesting. Such topics can be debated indefinitely. The facts are that after 1880, the species, for reasons which will never be exactly known, went out like a light, and was finally doomed by 1900 at the very latest. There is an amazing parallel with the Heath Hen here. When perfectly protected, with no effort and expense spared, and apparently doing very well, it too went out like a light, leaving us to wonder as to just why.

In preparation for this review, I have reread Mershon's early book, and all of Forbush's writing. Mr. Schorger's book is incomparably superior. It is far more complete and detailed than Mershon's, and while there is no effort at fine or dramatic writing as in Forbush, the latter was utterly lacking in any critical faculty requiring a balanced judgment. The present work exudes a wholesome atmosphere of this judgment, and the very late reviewer must close with an expression of wholehearted admiration at the happy completion of so scholarly, painstaking, and laborious a work.—Ludlow Griscom.

Migration and Distribution. A Study of the Recent Immigration and Dispersal of the Scandinavian Avifauna. (Flyttning och utbredning.) GUNNAR OTTERLIND. 1954. Vår Fågelvärld, 13: 1–13, 83–113, 147–167, 245–261. Detailed English summary. Previous work on this problem is reviewed extensively and recent observations studied and analysed. The extension from north to south of the Scandinavian Peninsula and its abrupt coastal borders are especially favorable conditions for such a study. It is argued that, in general, climatic variations are responsible for the changes which have occurred in the avifaunal ranges through prolonged migration during the past 100 years. Some changes have also taken place through abbreviated migration, but these are more difficult to determine.

With regard to the prolonged migration, the extension of the ranges northwards and westwards has been most conspicuous. Various causes of prolonged migration are discussed, such as the drying out of lakes and marshes, especially in Asia, the increased cultivation, the climatic changes, etc. Overpopulation often influences prolonged migration. First-year birds which lack strongly developed territorial faithfulness become the pioneers. Highly favored habitats are first occupied, and for this reason the young bird may often be forced to move on along with the migratory movement while some of its companions settle on less favorable territories. High spring temperatures have a stimulating effect on the migratory drive. The sight of migrating individuals of other species often induces many birds to continue to move in the same direction, a phenomenon frequently observed along the coasts in places where migratory flights are more concentrated. Birds with a strong migratory drive, in the extensive meaning of the term, react more readily to any external factors prompting them to move past the place of birth or the territory held the previous year. Sometimes, therefore, the reason for prolonged migration may be that individuals with overly strong migratory drive tend to accumulate along the northern limits of the range and then "spill over" into adjacent territories. It is suggested that the tendency to disperse beyond the normal range of young birds in species like the herons, for example, is not the actual cause of their colonizing new territory, but rather the fact that as immatures they have usually stayed in these places for a considerable length of time and in this way acquire a "homing instinct" by a process similar to imprinting relative to this out-of-range locality.

Factors that influence prolonged migration in Scandinavia are: 1) the surrounding seas which have an inhibiting as well as a stimulating effect on bird movement, stimulating in the sense that once over water the migrant landbird must continue to the nearest land or perish; 2) the availability of desirable habitats in the direction of the migration movements; 3) flock migration which is not only individually stimulating, especially in connection with starting flights across bodies of water, but which also increases the chances of finding mates in new territories; 4) the daily rhythm of the birds, which, for example, increases the probability of successful pairing of the night-singing night migrant over that of a day-singing night migrant as the birds travel into new localities.

Sometimes a lack of species companions may cause extreme prolongation of migration, since, conversely, successful pairing quickly leads to the interruption of movement. An excessive wander urge in certain individuals is another reason for extreme prolongation; such an urge tends to eliminate these birds as it considerably diminishes their chances of survival.

Abbreviated migration, the author defines as a movement in the normal direction during spring migration which is interrupted before the birth-place or the breeding-grounds of a previous year are reached. The cause for this type of migration is to

be found chiefly in unusually adverse weather conditions. When migration is thus interrupted, it causes an accumulation of migrants with an abundance of species companions which, in turn, inhibits the migration drive. This seems the least plausible of the arguments since many delayed arrivals to former territories have been noted in marked birds.

Undoubtedly, many of the hypotheses put forward in this paper are well founded on the studies and extensive field-work of Scandinavian ornithologists who, probably just because of the suitable topography of their Peninsula, have always been particularly interested in the problems related to the movements and range changes of their avifauna. With its many imaginative suggestions and deductions, it may serve to emphasize certain aspects of this vast problem which will prove useful in future research, and it must be considered a significant contribution towards the better understanding of birds' movements and dispersal.—LOUISE DE KIRILINE LAWRENCE.

Birds of the Ussuril Region.—K. A. Vorob'ev. Moscow, 1954. pp. 1–360, including 74 black and white figures, 19 color plates, 46 distribution maps, bibliography, contents, and list of species (in Russian, no foreign language summaries). —Of the increasing number of books from the Russian ornithological literature which are becoming available in the United States, the volume under review hits a high water mark with respect to quality of paper and binding, clarity of type, and general attractiveness of design. Unsatisfactory reproduction of the few landscape photographs included in this volume is more than offset by the excellence of the color plates. The artistry of A. Komarov and N. Kondakov has been reproduced with better success that this reviewer has yet seen (not excepting the fairly adequate color reproductions in the 6-volume 'Birds of the Soviet Union' by Dement' ev, Gladkov, *et al.*, 1951–54). This feature alone commends the volume to the attention of American bird students.

The first chapter consists of a history of the progress of ornithology in the Ussuri region during the past 100 years, from Schrenk (1854–56), Radde (1855–59), Maak (1855–59), Przheval'skii (1867–69), Arsen'ev (1910), Buturlin (1938), up to contemporary workers in the area, the author and his colleagues.

Chapter two, the main portion of the book, consists of brief commentaries on each of the 353 species which have been recorded in the area (roughly, the region between Nikolaevsk, Vladivostok, and Blagoveshchensk). A large number of the species dealt with are dismissed with a paragraph or two. The section on Brünnich's Murre is quoted in it's entirety as a typical example:

"172. Brünnich's Murre. *Uria lomvia arra* Pall. As in the preceding species [*U. aalge*], this murre nests along the Northern shore of the Maritime Province. There is one specimen of this species in the collections of V. K. Arsen'ev. It was taken on 28 July, 1909, in a large nesting colony near Tumnin River. The details of distribution of these two murres along the coast of the Maritime Province as well as their abundance and the character of their residence here has not been clarified up to the present time."

Other species, particularly those which are endemic to eastern Siberia, are discussed more fully. The section on the Scaly Merganser (*Mergus squamatus*), for example, distinguishes between this species and *M. serrator* on the basis of the distance from gape to nostril and a table of measurements for this feature is supplied. There is also included under this species a habitat sketch plus a clear and instructive figure comparing the flank feathers of *M. squamatus* with those of both male and female *M. serrator*. The nesting habits, migration dates, and field identification marks

are discussed. *Falcipennis*, as would be expected, is treated more fully than most of the species. The observations of this interesting grouse by early voyagers as well as contemporary ornithologists are quoted concerning the remarkable stupidity ("trustfulness" Vorob'ev calls it) which enables one to catch *Falcipennis* with a loop of twine on the end of a stick. Data on the food, habitat preference, vertical distribution, mating call, and an excellent black and white sketch are included. Another interesting two pages concerns the Pheasant (*Phasianus colchicus pallasi*) which appears to be extending its range into those areas of the Maritime Province where agriculture is replacing forest land. There are some comments on the food regime of this species (which includes young potatoes and many other items), its cycles of abundance, and it's autumnal, vagrancy type, migrations.

The fourth chapter is entitled: "General Review of the Avifauna of the Ussuri Region and Zoogeographic Analysis thereof." This chapter includes some interesting notes drawn from early day observations plus contemporary work which reveal phenomena such as changes in the specific composition of a heron nesting colony first noted by Przheval'skii in 1869. "The specific composition of this colony has changed at the present time: the Spoonbill is now completely absent as a nesting bird, but the Purple Heron (*Ardea purpurea manillensis*) is beginning to nest, having been found nesting here first by L. M. Shul'pin." The value of this chapter is substantially reinforced by a group of tidy distribution maps covering 45 species which reach the northern or southern limits of their range in the area under study. As would be expected, the valley of the Amur carries some species a little north and east of their "normal" ranges and, conversely, the Sikhote-Alin ridge carries some south, giving, on a smaller scale, a juxtaposition of valley and mountain avifauna similar in some ways to that in northern California.

With respect to nomenclature, the reviewer expected Vorob'ev to follow rather closely the comprehensive work of Dement'ev, Gladkov, *et al.* However, this is not the case. Vorob'ev uses *Nyroca* for the scaups and *Podiceps* for the grebes (*cristatus, grisegena, auritus, ruficollis*, and *caspicus*), whereas Dement'ev, Gladkov, *et al.*, use *Aythya* and *Colymbus* for the these genera. There are other similar adjustments (we hesitate to say corrections) throughout the book. With respect to common Russian names, the student who takes an interest in such matters will find much material for thought and some intriguing popular designations. *Uria lomvia* and *U. aalge* are called the Short-billed Kaira and Long-billed Kaira, respectively; *Cepphus carbo* and *C. columba* are referred to as Spectacled Chistik and Pacific Chistik. It is interesting that a generic distinction between *Uria* and *Cepphus* is made in the common name, thereby following American custom (Murre and Guillemot) rather than the European, which frequently uses Guillemot to refer to all four of the species involved. *Calidris alpina*, known commonly as Dunlin in England and Red-backed Sandpiper in America, appears under the apt title of Chernozobik (literally "black-breaster") in contradistinction to the Krasnozobik ("red-breaster") referring to *Calidris testacea*, the Curlew Sandpiper.

The title and format of this volume lead one to expect systematically organized descriptive material which would render it comparable to area guides such as those produced for many of our states by Forbush, Chapman, Hoffman, Howell, Bailey, and many others. Without the descriptive material it does not fall in this category. Nevertheless, it is a significant collection of notes on the birds of Northeast Asia and also serves as an excellent review of the status of the science in that part of the world, pointing out by implication (and in many cases directly) where future field work can fill in gaps in our knowledge of a rich and fascinating avifauna.—DAVID NICHOLS.

North American Birds of Prey.—Alexander Sprunt, Jr. Foreword by Roger Tory Peterson. Sponsored by The National Audubon Society. New York: Harper and Brothers, xxii + 227 pp., 43 color, 4 half-tone plates, 1955. Price, $5.00.—So long as the crying need for adequate protection of our birds of prey exists, there will be need for such a work as Alexander Sprunt's "North American Birds of Prey." This attractive work is, as is stated on the title page, "based on and supplementary to 'The Hawks of North America' by John Bichard May," published in 1935. It does not depart widely from the treatment given the subject by Dr. May, beyond extending the scope of the work to include the owls, and adopting the nomenclature of the forthcoming fifth edition of the "A.O.U. Check-List." It brings up to date the situation regarding the battle for adequate protection of our vanishing birds of prey, and includes an appendix covering the state and provincial laws relating to bird protection by Kenneth D. Morrison, as well as a brief bibliography. Unfortunately, the cuts illustrating the winter and summer ranges of the different species contained in Dr. May's work have been omitted.

The appendix amply demonstrates how much educational work remains to be done before we can expect proper enforcement of adequate laws to discourage the senseless slaughter of all our birds of prey that continues over most of this continent, where the battle cry of the average man with a gun is still, "If it isn't game, it must be vermin."

In the opinion of this reviewer, the present work does not sufficiently dwell upon the seriousness of the situation in some of the northern and western states, where efforts in education made at Hawk Mountain and Cape May have only driven the hawk shooters to more isolated points where the slaughter cheerfully persists.

It is indeed unfortunate that so many of our state game organizations draw their financial support from the license fees of the gunners and are, in far too many cases, subject to undue pressure from so-called sportsmen's organizations, whose interests are confined to providing more and better hunting rather than toward a broader program of conserving our heritage of wildlife for future generations. It is to these, but especially to schools, youth groups, and farmer's organizations that the present work is addressed.

As in Dr. May's work, there is a concise resume of the whole hawk and owl question, and a systematic treatment of all the species and subspecies of hawks, eagles, vultures, and owls inhabiting North America, with full descriptions of their appearance in the field and in the hand, their nesting, range, and feeding habits.

The work is handsomely embellished with forty-three full-page color plates by Allan Brooks, thirty-seven of which were used previously in Dr. May's work, two by Louis Fuertes, and four half-tone plates by Roger T. Peterson, who also provided the foreword. It should be in the hands of everyone who wishes to keep informed on the present status of our birds of prey; and in every public and school library, with the hope that it may help to bring the rising generation to an appreciation of the place that these birds play in nature's economy—before it is too late to do anything about it.—Earl L. Poole, *Director, The Reading Public Museum and Art Gallery, Reading, Pennsylvania.*

(For a different point of view on this book, see Parkes, Wilson Bull., 68: 83–84, 1956. Ed.)

Birds of Eastern and North Eastern Africa.—Volume Two of Series One of the African Handbook of Birds. C. W. Mackworth-Praed and Capt. C. H. B. Grant. (Longmans, Green and Co., London) vii + 1099 pp., 43 color pls., 13 photo pls., numerous text figures and maps, 1955. Price, 45 shillings.—The second and final

volume of this handsome and useful field reference covers 825 species from the larks to the buntings. The format follows the pattern of the first volume [see Auk, 72: 307–308, 1955, for review. Ed.] and presents a concise summary of the available information on distribution, habits, habitats, nest and eggs, breeding season, food, and calls. The marginal distribution maps are a particularly valuable feature. An introductory paragraph and a key to the species of each family are instructive and well organized. Each of the color plates depicts fifteen or twenty birds. They are, for the most part, well executed and so arranged as to provide a basis for direct comparison. This represents a considerable improvement over the reduced pictorial plates used in the first volume. The absence of a scale of size on these plates may cause some confusion among amateur observers comparing, for example, a 2½ inch illustration of a tit on Plate 77 with a 1½ inch illustration of a bush shrike on Plate 76. Seventy-eight excellent photographs by V. G. L. Van Someren depict a wide variety of birds, mostly at their nests, and constitute a valuable feature of the volume despite their reduced size.

A flyer enclosed with the book announces that the second series of the Handbook, a two-volume work on the birds of the southern third of Africa, is "in an advanced stage of preparation."—JOHN T. EMLEN, JR.

The Waterfowl of the World. Volume One.—Jean Delacour. London: Country Life Limited. 284 pp., 16 colored plates by Peter Scott, and 33 distribution maps. Price, five guineas.—In 1945, when Delacour and Mayr published their important paper on the family Anatidae (Wilson Bull., 57: 3–55), little of the evidence on which they based their reclassification was presented, presumably owing to lack of space. The senior author of this paper has now published the first of three volumes which, to quote the jacket blurb "will provide a synthesis of all that is known of the waterfowl of the world as they exist at the present time." This first volume, covering the Magpie Goose (*Anseranas*), the whistling ducks (tree ducks), swans, true geese, and sheldgeese and shelducks, is noteworthy in being the only available work covering all the forms of geese and swans in the world. However, it is disappointing to those who look for more of the evidence on which the earlier classification was based or those who expect to find a complete summary of our knowledge of these birds' life histories and habits.

The major categories—subfamilies, tribes, and genera—are characterized. In the accounts of polytypic genera, keys to the species are provided, and these are followed by short sections on "general habits" and "captivity." Species and subspecies are treated more fully, and the general distribution of each form is shown on a map. Delacour is well known as an aviculturist and conservationist, so it is not surprising to find much information on the history and general characteristics of each species in captivity and on the status and history of rare and extinct forms.

A major contribution is the set of colored plates depicting the downy young. These and the colored figures of the adults of each form were painted by Peter Scott, whose experience with waterfowl in the wild and in captivity is second to none. The frontispiece of "Pinkfeet in Their Winter Quarters in England," with its unusually beautiful treatment of light, is a fine example of Scott's art. The semidiagrammatic illustrations of the individual species are less successful: whereas the poses are authentic, the bright backgrounds make accurate color comparisons difficult and the colors of some of the birds (notably the Crested Ducks) are very inaccurately represented. The latter may be in part the fault of the printer, nevertheless, Scott appears to be one of those rare individuals whose ability as an artist far excels his ability as an illustrator.

Much of the evidence on which Delacour and Mayr based their classification of the waterfowl was related to courtship and other displays. It is disappointing to find only the most general descriptions of these displays under the accounts of the genera and even more disappointing to read of the Hawaiian Goose, for instance, (p. 147) that "In its ways and behaviour, it resembles the Canada Goose to a great extent, but it has characteristics of its own; the voice is rather different, as is the display" and not to be told *how* it differs. There is a real need for a series of sketches and descriptions of the characteristic displays of each group of species. Delacour and Scott are extraordinarily well equipped to prepare such an analysis, and it is to be hoped that one of the remaining volumes will contain it.

The book has been so beautifully printed and bound that collectors of fine bird books will want to own it. Aviculturists, birders, and sportsmen who want to learn more about waterfowl will find much to interest them in it, but the more serious students of birds will probably be disappointed in the paucity of specific details to document many of the broad statements which the book contains.—ROBERT W. STORER.

The Species of Middle America Birds.—Eugene Eisenmann. Trans. Linnaean Soc. N. Y. 7, vi + 128 pp. April, 1955. Price, $2.00.—There has long been a need for an up-to-date list of the birds of Middle America, and within the limits set by the author, this work fills the need very well. A brief introduction in which are discussed the procedure used in preparing the list and comments on the distribution of birds in Middle America precedes the list itself. After ordinal and family headings, the species are listed by scientific and vernacular names. A brief statement (usually not more than a line) of the range is given. Subspecies are not mentioned, but there are many footnotes which call attention to unsolved taxonomic problems. A useful twelve-page bibliography and an index end the work.

It is obvious that much thought and care have gone into the preparation of this publication. This is particularly true in the case of the selection of the vernacular names. With the passing of such names as Natterer's Chatterer and the Lesser Hairy Hermit, some of the flavor may have gone out of Central American ornithology; but we have Eisenmann to thank for eliminating subspecific vernaculars. This is a healthy trend and one which is becoming more general on this continent. It is to be hoped that the authors of the second part of the Mexican check-list will drop the useless and frequently absurd subspecific vernaculars in Spanish which are apparently being coined expressly for their list and which will never come into anything approaching general use.

One may disagree with Eisenmann on his choice of names (and I for one strongly object to the use of "woodcreepers" for the dendrocolaptids), but the names were not lightly chosen. In most cases the name selected was already in the literature and was decided upon only after consultation with several other workers.

'The Species of Middle American Birds' is a worthy successor to the earlier Transactions of the Linnaean Society of New York and is a work which will be useful for many years.—ROBERT W. STORER.

The Birds of the British Isles. Volume Four.—David Armitage Bannerman. (Oliver and Boyd, Edinburgh), xii + 259 pp., 29 colored plates by George E. Lodge. Price, 45 shillings.—The fourth volume of this work covers the swifts, nightjars, bee-eaters, hoopoes, rollers, kingfishers, woodpeckers, cuckoos, and owls. The format and treatment are similar to those of the first volume (see Auk, 71: 216–217, 1954). At least two more volumes are projected to treat the remaining non-passerines.—ROBERT W. STORER.

RECENT LITERATURE

EDITED BY FRANK McKINNEY

Anatomy and Embryology

Auber, L. 1955. Cortex and medulla of bird-feathers. Nature, **176:** 1218–1219.—Differential staining brings out the differences between cortex and medulla; some earlier misconceptions of feather structure can thus be corrected.—H. C. S.

Bellairs, A. d'A. 1955. Skull development in chick embryos after ablation of one eye. Nature, **176:** 658–659.

Fisher, H. I. 1955. Some aspects of the kinetics in the jaws of birds. Wilson Bull., **67:** 175–188, 4 fig., 6 tables.—Methods for studying the movement of the upper bill were determined, and some anatomy affecting the movement is described.—J. T. T.

Glenny, F. H. 1955. Modifications of pattern in the aortic arch system of birds and their phylogenetic significance. Proc. U. S. Natl. Mus., **104:** 525–621, 12 figs.—A bringing together of the widely scattered literature on the carotid arteries of birds and a discussion of the evolution of the various arrangements of these vessels.—R. W. S.

Hilton, W. A. 1955. A note on the brain plexuses of birds. Bull. Southern Calif. Acad. of Sciences, **54:** 113–116, pl. 31.

Hudson, G. E., and P. J. Lanzillotti. 1955. Gross anatomy of the wing muscles in the Family Corvidae. Amer. Midland Nat., **53:** 1–44, 35 figs.—An important comparative study of 19 species and subspecies of corvids, all but 2 of which are American.—R. W. S.

Mosier, H. D. 1955. The development of the hypothalamo-neurohypophyseal secretory system in the chick embryo. Endocrin., **57:** 661–669.

Schechtman, A. M., and P. F. Knight. 1955. Transfer of proteins from the yolk to the chick embryo. Nature, **176:** 786–787.

Behavior

Aschoff, J., and J. Meyer-Lohmann. 1955. Die Aktivität gekäfigter Grünfinken im 24-Stunden-Tag bei unterschiedlich langer Lichtzeit mit und ohne Dämmerung. Zeitschr. f. Tierpsychol., **12:** 254–265.—English summary. The locomotor activity of caged Greenfinches (*Chloris chloris* L.) was studied experimentally by manipulating the day length. During a light period of 8 hours per day birds showed highest activity per light-hour, during a light period of 12 hours per day the highest total activity per 24 hours.—F. M.

Engelmann, C. 1955. Versuche über den Gesichtskreis der Gans. Zeitschr. f. Tierpsychol., **12:** 266–276.—English summary. Experiments on domestic geese, ducks, and chickens show the distances at which they recognize a white plate, grain, and fellow members of their species. Geese see distant goals better than chickens or ducks, but chickens are best at recognizing objects which are quite near.—F. M.

Ewer, R. F. 1956. Imprinting in animal behaviour. Nature, **177:** 228–229.—Some suggestions are offered on the relationship of imprinting to the evolution and natural selection of learning and instinctive behavior.—H. C. S.

Frings, H., M. Frings, B. Cox, and L. Peissner. 1955. Auditory and visual mechanisms in food-finding behavior of the Herring Gull. Wilson Bull., **67:** 155–170, 3 figs.—Gulls (*Larus argentatus*) first found food by sight. The actions of the finder attracted other gulls, but more effective was a food-finding call

which attracted gulls from distances up to 3 to 5 km. Notes on other calls are included.—J. T. T.

GEWALT, W. 1955. Droh- und Kampfverhalten des Brachvogels (*Numenius arquata* L.) gegenüber der Grosstrappe (*Otis tarda* L.) Zeitschr. f. Tierpsychol., **12**: 277–285.—English summary. Nesting Curlews attack Bustards by pecking toward the cloaca. This reaction was investigated in captive birds. Threat postures occur when attack is inhibited. Threat-crouching resembles some courtship movements of *Numenius* and related species. Other hostile behavior patterns are described. Illustrated by excellent photographs.—F. M.

MARLER, P. 1955. Characteristics of some animal calls. Nature, **176**: 6–8.—Birds' sounds are utilized to facilitate location or to confuse location. The physical properties of sound and of hearing are analyzed to show how these contrasting properties are achieved.—H. C. S.

MCNAMARA, E. 1955. Function of the bower of bower-birds. Nature, **176**: 207.—Observation of copulation occurring in the bower of the Satin Bowerbird.—H. C. S.

SAUNDERS, A. A. 1955. An analysis of the songs of meadowlarks. Wilson Bull., **67**: 303–304, 1 fig.—Songs of the Southern Meadowlark (*Sturnella magna argutula*) are intermediate in some characteristics between those of the Eastern Meadowlark (*S. m. magna*) and the Western Meadowlark (*Sturnella neglecta*).—J. T. T.

ZIMMERMAN, D. A. 1955. Notes on field identification and comparative behavior of shrikes in winter. Wilson Bull., **67**: 200–208, 4 figs.—*Lanius excubitor* and *L. ludovicianus*.

DISEASES AND PARASITES

COIL, W. H. 1955. The morphology of *Cyclustera capito* (Rudolphi, 1819) Fuhrmann 1901. Trans. Am. Micros. Soc., **74**: 353–357.—Cestodes from Roseate Spoonbills (*Ajaia ajaja*).

HANSON, H. C., N. D. LEVINE, and S. KANTOR. 1956. Filariae in a wintering flock of Canada Geese. Journ. Wildl. Mgt., **20**: 89–92.—The incidence of Microfilariae of *Ornithofilaria* (?) sp. in the blood of *Branta canadensis*. *Sarconema eurycerca* was present in yearlings and adults only.—J. J. H.

SCHELL, S. C. 1955. *Schistotaenia colymba*, n. sp. from the Horned Grebe (*Colymbus auritus* L.) Trans. Am. Micros. Soc., **74**: 347–350.

SELANDER, R. K. 1955. The occurrence of the parasite Sarcocystis in Mexican birds. Amer. Midland Nat., **54**: 252–253.—The cyst-forming *Sarcocystis* ("until recently believed to be a protozoan but now considered by many to be a fungus") was found in 1.68 per cent of 119 *Campylorhynchus chiapensis*, 1.49 per cent of 268 *C. rufinucha*, 14.3 per cent of 7 *Saltator coerulescens*, and 66.6 per cent of 3 *Synallaxis erythrothorax*. All specimens were collected at random.—D. A. Z.

DISTRIBUTION

ALDRICH, J. W., and A. J. DUVALL. 1955. Distribution of American gallinaceous game birds. 23 pp., 7 pl. (U. S. Fish and Wildlife Service, Washington, D. C.) Price, 30 cents.—Includes well-prepared distribution maps and brief comments on range and habitat of 21 U. S. species.—D. A. Z.

ALI, S. 1955. The birds of Gujarat, part II. Journ. Bombay Nat. Hist. Soc., **52**: 736–802.—Annotated list dealing with the Hirundinidae, Campephagidae, Irenidae, Pycnonotidae, Muscicapidae (incl. Muscicapinae, Timaliinae, Sylviinae, Turdinae), Motacillidae, Laniidae, Sittidae, Paridae, Dicaeidae, Nectariniidae,

Zosteropidae, Fringillidae, Ploceidae, Sturnidae, Oriolidae, Dicruridae, and Corvidae in this western Indian region.—D. A. Z.

BATEMAN, B. 1953. Observations on the natural history of the Leaf Bay—Fort Chimo Region, Ungava, Quebec. Intermediate Naturalist, **8**: 1–7.—Includes an annotated list of 38 bird species observed between June 20 and Sept. 18, 1953; contains numerous breeding records.—D. A. Z.

BEHLE, W. H. 1955. The birds of the Deep Creek Mountains of central western Utah. (Univ. of Utah Biol. Ser. Vol. 11, No. 4, 34 pp.)—An annotated list of 147 forms (145 species) and a brief description of the region.—D. A. Z.

DAVIS, W. B., and R. J. RUSSELL. 1953. Aves y mamiferos del estado de Morelos. Revista de la sociedad Mexicana de historia natural, **14** (1–4): 77–147.—Annotated lists (in Spanish) of 237 forms of birds and 68 mammals based on material collected by Davis and others. The unusually large number of mistakes in spelling casts some doubt on the reliability of data presented in this translation.—D. A. Z.

FABLES, D., JR. 1955. Annotated list of New Jersey birds. (Urner Ornithological Club.) xi + 95 pp., 4 figs., 3 maps.—The 370 species recorded "up to and including September 1, 1954," include at least 12 whose New Jersey status apparently rests upon sight records alone. Additional subspecies, hybrids, and species on on the hypothetical list bring the total number of forms to 421. Subspecies are mentioned (under the species accounts) only "when races are represented in collections," but it is not stated if specimens were critically determined by a taxonomist. A very brief geographical and ecological discussion of the state, a bar graph showing periods of maximum abundance of most species, a check-list of "birds I have seen in New Jersey" (oddly including, extinct, extirpated, and accidental species) supplement the annotated list.—D. A. Z.

FRADE, F. 1951. Aves coligidas pela Missão Zoologica de Moçambique. Junta das Missões Geograficas e de Investigações Colonias, Lisboa, vol. **6**, pt. 4, fasc. 3, pp. 1–220.—An annotated catalog of the specimens of 236 forms of birds collected, together with summaries of earlier published records, and with occasional discussion of variations, distribution, etc. There are no field notes on the habits of the birds.—H. F.

FRADE, F. 1951. Catalogo das Aves de Moçambique. Junta das Missões Geograficas e de Investigações Colonias, Lisboa, vol. **6**, pt. 4, fasc. 4, pp. 1–294.—Lists 800 species and subspecies of birds from Mozambique. The account of each form is merely a list of all the records known to the author with the pertinent literature references. There is no discussion, no attempt to summarize the local distribution or status (whether breeding, wintering, migrant), no indication even of whether or not the author had an opportunity to examine critically the validity of many of the races he includes on the basis of earlier published identifications. There is an introductory chapter with a brief biogeographic account of the country, and a bibliography, but the list can only be looked upon as a convenient point of departure for future work rather than as a firmly established basis to which to add.—H. F.

FRIEDMANN, H., and F. D. SMITH, JR. 1955. A further contribution to the ornithology of northeastern Venezuela. Proc. U. S. Natl. Mus. 104 (No. 3345): 463–524.—An annotated list of forms collected by Smith since the 1950 report on this region by these authors. Also includes a complete list of the known avifauna of the region.—D. A. Z.

HAVERSCHMIDT, F. 1955. List of the birds of Surinam (Ut recht. Foundation for Scientific Research in Surinam and the Netherlands An tilles Publ. No. 13.) 153

pp.—An annotated list of 536 species. There is a 4-page annotated bibliography and a map.—D. A. Z.

HUMMELINCK, P. W. 1952. Islote Aves, een vogeleiland in de Caraïbische Zee. De West-Indische Gids, **33**: 23–34.—An account of a visit to "Bird Island" west of Dominica, May 12, 1949. "This key is composed of coral sand, partly cemented into a soft, calcareous sandstone . . .," and is a nesting ground of many *Anoüs stolidus* and *Sterna fuscata*. Some nests of *Larus atricilla* were found.—D. A. Z.

RAND, A. L., and M. A. TRAYLOR. 1954. Manual de las aves de El Salvador (University of El Salvador). 308 pp. Illustrations (previously published in Blake's, Birds of Mexico, 1953) by D. E. Tibbitts.—Keys to, descriptions of, and general remarks on 393 species.—D. A. Z.

SABATER PI, J. 1954. Notas para un estudio de los indicadores de miel (Familia Indicatoridae) de la Guinea Española. Archivos del Instituto de Estudios Africanos **7**, No. 30, pp. 7–12.—Six species of honey-guides are listed from Spanish Guinea, but for two of them, *Melichneutes robustus* and *Melignomon zenkeri*, there are no actual records. No new facts about the birds are given.—H. F.

SCHAANNING, H. T. L. 1954. A contribution to the ornithology of eastern Siberia. Nytt Magasin for Zoologi, **2**: 91–115.—Annotated list of 85 forms. Translated into English from the Norwegian manuscript by Dr. Y. Hagen. "Based on the collections made by Mr. Johan Koren in Kolyma in 1914–1918."—D. A. Z.

SCHOUTEDEN, H. 1955. Les Indicatorides congolais. Rev. Zool. Bot. Afr., vol. **51**, pp. 397–400.—Additional specimen locality records from the Belgian Congo for the various species and races of honey-guides found there.—H. F.

SCHOUTEDEN, H. 1955. Quelques oiseaux de la faune congolais. Rev. Zool. Bot. Afr., vol. **51**, pp. 401–405.—Notes on the occurrence and the distribution of nine species of land birds. Range of *Laniarius mfumbiri* extends to Ruanda.—H. F.

SMITH, H. R., and P. W. PARMALEE. 1955. A distributional check list of the birds of Illinois. (Ill. State Mus. Popular Sci. Ser. vol. 4, 62 pp.)—384 species, "91 of which are now considered extinct or 'accidental' within the state." More than 30 are included solely on the basis of sight records. Numerous other species "usually not observed within the state boundaries each year" are indicated by a special symbol. These include species represented by extant specimens as well as those whose Illinois status rests only on early references to specimens evidently not examined by the authors. There is a 4-page list of literature cited.—D. A. Z.

VAN HOOSE, S. G. 1955. Distributional and breeding records of some birds from Coahuila. Wilson Bull., **67**: 302–303.—Notes on eleven species.

YEPEZ TAMAYO, G. 1955. El orden Ciconiiformes y sus representantes en Venezuela. Memoria de la Sociedad de Ciencias Naturales la Salle **15** (No. 40): 5–44. (In Spanish with brief English summary.)—An account of the ordinal, subordinal, and family characters, in addition to descriptive and distributional information on each species. Some specimens are cited.—D. A. Z.

ECOLOGY AND POPULATION

BETTS, M. M. 1955. The food of titmice in oak woodland. Journ. Animal Ecol., **24**: 282–323.—Stomach analyses showed that competition for food between *Parus major*, *P. caeruleus*, *P. ater*, and *P. palustris* was largely avoided because of differences in food preferences and in the stratum where it was sought. The amount of predation on defoliating caterpillars did not exceed 4.8 per cent of the caterpillar population.—S. C. K.

GOLLEY, F. B., and P. A. JOHNSGARD. 1955. Fall distribution of birds in a Palouse River canyon. Ecol., **36**: 754–755.—Relation of bird populations of different species to types of vegetation.—S. C. K.

GOODNIGHT, C. J., and M. L. GOODNIGHT. 1956. Some observations in a tropical rain forest in Chiapas, Mexico. Ecol., **37**: 139–150.—Characteristic birds of the high forest, ground and low vegetation, and forest-edge are listed.—S. C. K.

JOHNSTON, D. W., and E. P. ODUM. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecol., **37**: 50–62.—Densities of 15–40 pairs per 100 acres in recently abandoned fields increased to 136 in shrublands, decreased to 87–93 in young pine forests, increased to 239 in 100-year-old pine and 228 in a young oak-hickory forest. Winter densities were higher in all vegetation types except the oak-hickory forest. Forest-edge species are those that require for their breeding territories a combination of two or more communities of widely different age. Forest-edge species constitute 30–40 per cent of the common breeding species of the region.—S. C. K.

LANYON, W. E. 1956. Ecological aspects of the sympatric distribution of meadowlarks in the north-central states. Ecol., **37**: 98–108.—The Western Meadowlark has extended its range northeastward during the last 50 years, replacing the Eastern Meadowlark in certain areas. Where the ranges of the two species overlap, the Western Meadowlark selects the more xeric sites and the Eastern Meadowlark the moister ones.—S. C. K.

SPRUNT, A., JR. 1955. The spread of the Cattle Egret. Smithsonian Inst. Ann. Report for 1954: 259–276.—A summary, with emphasis on the New World. Includes brief comments on food, competition with other species, and other topics. Possibly the first *Bubulcus ibis* to breed in North America were those seen in Florida in 1941 or 1942, though no breeding evidence was obtained until 1953. This continent's Cattle Egret population was estimated to be about 2,000 birds in July, 1954. Apparently the first known South American nests were found in British Guiana in 1950. All New World specimens taken are *B. i. ibis*.—D. A. Z.

WING, L. W. 1955. Latitudinal slippage of Bob-white, Hairy Woodpecker, and Downy Woodpecker cycles. Journ. Cycle Research, **4** (1): 3–31.—An attempt to correlate U. S. and Canadian Christmas census data ("as birds per hour of censusing, 1900–1939") with temperature cycles.—D. A. Z.

EVOLUTION AND GENETICS

GOSLIN, R. M. 1955. Animal remains from Ohio rock shelters. Ohio Journ. Sci., **55**: 358–362.—Among the bird remains found in rock shelters in Hocking, Fairfield, Jackson, and Summit counties were those of the Raven, Wild Turkey, Passenger Pigeon, Trumpeter Swan, Prairie Chicken, Swallow-tailed Kite, and Mississippi Kite.—H. C. S.

UDAGAWA, T. 1955. Karyogram studies in birds. V. The chromosomes of five passerine birds. Annot. Zool. Jap., **28**: 19–25.—*Motacilla grandis, M. cinerea caspica, Muscicapa c. cyanomelana, Horeites c. cantans,* and *Turdus naumanni eunomus*.—R. W. S.

GENERAL BIOLOGY

BIAGGI, V., JR. 1955. The Puerto Rican Honeycreeper (Reinita) *Coereba flaveola portoricensis* (Bryant). Univ. Puerto Rico, Agric. Expt. Sta., Special Publ., 61 pp.—Data on nest construction, attentiveness during incubation and care of the young, and the growth of nestlings are presented. Brief treatment of some other topics such as roosting and territory.—F. M.

BRECKENRIDGE, W. J. 1956. Nesting study of Wood Ducks. Journ. Wildl. Mgt., **20**: 16–21.—Three-year study of attentiveness of *Aix sponsa* by means of automatic recording apparatus. Shortest incubation period (25 days) was recorded when no major disturbance of the hen took place. Periods of 29–30 and 31 days resulted from disturbance of nest and serious chilling of the eggs. For a given species, the shortest incubation period is a biological constant that should not be confused with its longer ecological variants. Recommended phrasing for the period in this species: "25 days and longer"; not: "from 25 to 31 days."—J. J. H.

DAVIS, D. E. 1955. Population changes and roosting time of Starlings. Ecol., **36**: 423–430.—No correlation obtained between roosting time and photometer readings. Highest roosting populations occurred in September and January.—S. C. K.

HERROELEN, P. 1955. Over de Grote Gele Kwikstaart. *Motacilla cinerea* Tunst. Gerfaut, **45**: 117–126.—Notes on the Gray Wagtail in Belgium. One male weighed 18 gm. and two females, 14 and 25 gm. Banding has shown that adults winter in Belgium, young may migrate to England, and birds from Germany may winter in Ardennes. Fall migration starts in August; spring migration occurs from February to the end of April.

Nests are built near watercourses and from 0.5 to 10 meters above the water-level. Construction takes 5 to 12 days. The clutch size varies from 3 to 7, 5 and 6 are the most frequent, first sets tend to be smaller. Complete sets may be found from early April to the middle of July. As many as three sets may be laid in one season. Incubation begins with the laying of the last egg and lasts 12 to 13 days. The young remain in the nest 12 to 15 days. Two weeks after they depart, the female starts the second set. (In Dutch.)—R. W. G.

HORVÁTH, L. 1955. Red-footed Falcons in Ohat-Woods, near Hortobágy. Acta Zool. Acad. Scient. Hungaricae, I (fasc. 3–4), 243–287. (In English, with resumé in Russian.) *Falco vespertinus*, gregarious in nesting, occupied old nests of rooks, 110 pairs being congregated in 3 separate rookeries in a woodland 3 kilometers long by 400 to 900 meters broad. The pairs were grouped loosely, as many as five occupying nests in one tree. Two additional were found in nearby acacia groves using old magpie nests. The young were fed mainly on one species of frog (*Pelobates*), orthoptera and beetles, with occasional young birds and lizards. Rooks destroyed many eggs, many were infertile, leaving a nesting success of 45.7 per cent in 30 nests on which full data were secured. It was estimated that 176 young were reared from 110 nests. The falcons are migratory in eastern Hungary arriving about April 26, and leaving in small groups from August 21 to September 14.

MCCLURE, H. E. 1955. Sex and age ratios of some Japanese birds. Wilson Bull., **67**: 287–290, 2 tables.—Data are based on 3000 birds, mostly passerines. The sex ratio varied from month to month as the conspicuousness of each sex varied with nesting and other activities. The ratio of immature to adult birds showed a peak in August.—J. T. T.

PETERSON, A. J. 1955. The breeding cycle in the Bank Swallow. Wilson Bull., **67**: 235–286, 22 figs., 17 tables.—The nesting activities of *Riparia riparia* are described with accompanying physiological and histological changes.—J. T. T.

PORTUGAL ARAUJO, V. DE 1955. Existe em Angola um passaro inimigo das abelhas. *in* A Provincia de Angola, **31** (8651): 1–2.—Considers the Greater Honey-guide (*Indicator indicator*) an enemy of bees because it leads bee hunters to the hives. It should be mentioned that the author is an apiculturist, not an ornithologist.—H. F.

ROWAN, M. K. 1955. The breeding biology and behaviour of the Redwinged Starling *Onychognathus morio*. Ibis, **97**: 663–705.—Observations were made mainly at two nesting sites over four years at Hout Bay, Cape Peninsula, South Africa. The population is composed of resident pairs and roving flocks of juveniles. Territory is held against other pairs, but the flocks are ignored. Agression against other vertebrates is marked near the nest. Clutch-size in 19 nests was 3.05 eggs. Two clutches are laid, and the breeding season spans October and December. The female incubates alone. The incubation period is highly variable; in 14 nests it varied from 12½ to 23 days ($\bar{x}$ = 16). The fledging period is 26 days (22–28 days). 90.7 per cent of the eggs laid fledged young birds. Much detail on behavior at various stages of the breeding cycle is supplied.—R. F. J.

SWANK, W. G. 1955. Nesting and production of the Mourning Dove in Texas. Ecol., **36**: 495–505.—Study of nesting and annual production. Active nests were found in every month except November and December.—S. C. K.

TOMKINS, I. R. 1954. Life history notes on the American Oyster-catcher. Oriole, **19** (4): 38–44.—Fragmentary but important information on habitat requirements, courtship, and breeding habits. Incubation of one set of eggs lasted "about 28 days" after laying of the last egg; both sexes incubate; 3 eggs constitute a normal clutch; the young are fed on regurgitated oysters. Several comparisons are made with the European Oyster-catcher.—D. A. Z.

TOMKINS, I. R. 1955. The summer schedule of the Eastern Willet in Georgia. Wilson Bull., **67**: 291–296, 2 figs.—Description of the activities, including nesting, of *Catoptrophorus semipalmatus semipalmatus* during the three months these shorebirds are on the Georgia coast, with a few notes on migrant *C. s. inornatus*.—J. T. T.

TUCK, L. M., and H. J. SQUIRES. 1955. Food and feeding habits of Brünnich's Murre (*Uria lomvia lomvia*) on Akpatok Island. Journ. Fish. Res. Bd. Canada, **12**: 781–792.—A study based in part on food dropped by adult murres as they flew in to feed their young. This food was collected in a restricted area, daily. Some young were fed experimentally with this food; 13.4 grams were required to result in a gain in weight of one gram. Examination of stomach contents of 34 adults showed a predominance of crustaceans, but fish were also important in the adult diet.—D. A. Z.

WELLER, M. W., I. C. ADAMS, JR., and B. J. ROSE. 1955. Winter roosts of Marsh Hawks and Short-eared Owls in central Missouri. Wilson Bull., **67**: 189–193, 2 tables.—Up to 80 or 90 individuals of *Circus hudsonius* and 13 of *Asio flammeus* roosted on the ground in an area with an abundance of *Microtus*. Pellet analyses showed that *Microtus* was the primary food eaten.—J. T. T.

WHITAKER, L. M. 1955. Cardinal [*Richmondena cardinalis*] exploits Loggerhead Shrike's [*Lanius ludovicianus*] artificial food source. Wilson Bull., **67**: 213–214.—Food was raw meat or cheese.

MANAGEMENT AND CONSERVATION

BOHL, W. H. 1956. Experiments in locating wild Chukar Partridges by use of recorded calls. Journ. Wildl. Mgt., **20**: 83–85.—Hand-cranked phonograph utilizing a crystal pick-up and battery-operated loudspeaker gave promising results in a preliminary experiment.—J. J. H.

CAMPBELL, H., and L. LEE. 1956. Notes on the sex ratio of Gambel's and Scaled quail in New Mexico. Journ. Wildl. Mgt., **20**: 93–94.—For *Lophortyx g. gambelii*, males made up 51 per cent of the juveniles and 56 per cent of the adults. For *Callipepla squamata pallida* percentages were 47 (?) and 59 respectively.—J. J. H.

DORNEY, R. S., and H. M. MATTISON. 1956. Trapping techniques for Ruffed Grouse. Journ. Wildl. Mgt., **20**: 47–50.—Details of mirror traps on drumming logs of *Bonasa umbellus*, clover-leaf traps with leads in late summer and fall, and wooden bob-cages placed under leafy shelters in winter.—J. J. H.

GLOVER, F. A. 1956. Nesting and production of the Blue-winged Teal (*Anas discors* Linnaeus) in northwest Iowa. Journ. Wildlife Mgt., **20**: 28–46.—Females selected nest sites and built nests mostly from 7 to 10 A.M., 20 to 210 yards from water (aver. 79). Annual hatching success 21 and 23 per cent; mean number eggs hatched 9.3. Of 186 nests, 28 were judged to be renesting attempts. Young annually produced per breeding pair: 1.33 and 1.35. Nest predators were striped skunk, mink, raccoon. Mean brood size 6.2 at 2–3 weeks of age, 5.2 at 8–10 weeks. Six management procedures recommended.—J. J. H.

PETERLE, T. J. 1956. Trapping techniques and banding returns for Michigan Sharp-tailed Grouse. Journ. Wildl. Mgt., **20**: 50–55.—Tip-top was the most successful trap for *Pedioecetes phasianellus* in winter; cannon-projected nets, on dancing grounds in spring. Male birds were relatively sedentary; migrant winter flocks were thought to consist largely of females and young.—J. J. H.

SALOMONSEN, F. 1954. Den dansk vildtstatistik (The Danish game statistics). Dansk Ornith. Foren. Tidsskrift, **48**: 123–126.—"It appears that a total of about 2 million birds are shot by hunters annually in Denmark." Figures are given for various waterfowl, shore-birds, birds of prey, gulls, and certain other birds.—D. A. Z.

WIGHT, H. M. 1956. A field technique for bursal inspection of Mourning Doves. Journ. Wildl. Mgt., **20**: 94–95.

MIGRATION AND ORIENTATION

ARNOULD-TAYLOR, W. E., and A. M. MALEWSKI. 1955. The factor of topographical cues in bird homing experiments. Ecol., **36**: 641–646.—Suggests that topographical cues were involved in the homing experiments of Matthews, Kramer, St. Paul, and Hitchcock, which experiments some investigators have considered as giving evidence for a "special sense of direction" in birds.—S. C. K.

COOCH, G. 1955. Observation on the autumn migration of Blue Geese. Wilson Bull., **67**: 171–174, 1 fig.—Evidence that some flocks migrate from James Bay to the Gulf Coast in a single flight at fairly high altitudes.—J. T. T.

CROWELL, J. B., JR. 1955. Behavior of migrating birds at sea off San Diego, California. Wilson Bull., **67**: 305.—Five non-passerine and seven passerine species were observed a few miles at sea.

SALOMONSEN, F. 1954. The migration of the European Redshanks (*Tringa totanus* [L.]). Dansk Ornith. Foren. Tidsskrift, **48**: 94–122.—Recoveries of ringed Danish Redshanks show that the birds use two migration routes: one is along the coast of Holland, France, and Spain; the other is across the mainland "heading directly for the Mediterranean coast of France and the Adriatic coast of Italy." (This is also true for Danish populations of *Philomachus pugnax* and *Tringa glareola*.) The continental route is considered more important, yielding 96 recoveries, compared with 58 from the coastal route. Fall migration is early; birds sometimes reach wintering grounds in July. Birds using the continental route winter primarily in the Mediterranean region; those using the coastal route winter on the Atlantic coast of southern Europe. The winter distribution pattern is complex. "In W. Europe the populations winter at the Atlantic coasts in the same order in which the breeding areas are situated (Iceland birds north of British birds, etc.)" But Swedish and Norwegian populations winter in Africa, south

of all other populations. Spatial segregation of the different wintering quarters is believed to be of evolutionary importance. "In the Redshank the geographical variation in wing-length is due to selection in the winter-grounds." Average wing-lengths in the various wintering populations follow Bergmann's rule (increasing to the north), "but when arranged in the breeding areas the populations do not in their size variation follow any ecological rule."—D. A. Z.

SALOMONSEN, F. 1955. Sixth preliminary list of recoveries of birds ringed in Greenland. Dansk Ornith. Foren. Tidsskrift, **49**: 130–135. (In Danish with English summary.)—Recoveries of *Anser albifrons*, *Somateria* sp., *Larus glaucoides* (or *L. hyperboreus*), *Uria lomvia*, *Fratercula arctica*, *Oenanthe oenanthe*, and *Plectrophenax nivalis*.—D. A. Z.

WOODFORD, J. 1953. Migration of the Blue Jay. Intermediate Naturalist, **8**: 29.—In one ten-hour period on September 21, 1953, 9,735 *Cyanocitta cristata* were counted south of Amherstburg, Ontario. Most flew across the Detroit River and continued westward or southwestward. The majority flew along the shore until opposite Boblo Island before heading across, though a few crossed south of the island.—D. A. Z.

PHYSIOLOGY

DAS, B. C., and A. V. NALBANDOV. 1955. Responses of ovaries of immature chickens to avian and mammalian gonadotrophins. Endocrin., **57**: 705–710.

GOODWIN, K., R. K. COLE, F. B. HUTT, and B. A. RASMUSEN. 1955. Endocrine relationships in males of a relatively infertile strain of White Leghorn fowls. Endocrin., **57**: 519–526.

KOSAK, A. I. 1955. The extraction of the pigment from Touraco feathers by soap solution. Ohio Journ. Sci., **55**: 339.—An alkaline soap used to wash a female Touraco at the Cincinnati zoo caused the turacin to dissolve into the bath water.—H. C. S.

MARSHALL, A. J., and H. J. DE S. DISNEY. 1956. Photostimulation of an equatorial bird (*Quelea quelea*, Linnaeus). Nature, **177**: 143–144.—Male birds exposed to 17 hours of light daily showed testicular response; males given only 5 minutes additional daily light showed very little response compared to controls. Females failed to respond. It is concluded that Wolfson's summation hypothesis has no validity.—H. C. S.

WOODIN, A. M. 1955. The free amino-groups of soluble feather keratin. Nature, **176**: 1117.

TAXONOMY

BURMA, B. H. 1954. Reality, existence, and classification: a discussion of the species problem. Madroño, **12**: 193–209.—Because it is unlikely that the term *species*, "with its overpowering load of undesirable connotations," will be discarded, and "all taxonomic units of whatever kind should be recognized explicitly for what they are—arbitrarily erected, man-made constructs. . . . The idea of the reality of evolving populations of individuals should always be kept in the forefront of any discussion of the evolutionary process."—D. A. Z.

PARKES, K. C. 1955. Notes on the molts and plumages of the Sparrow Hawk. Wilson Bull., **67**: 194–199.—*Falco sparverius sparverius* has a post-juvenal body molt. Immature males may be recognized from adults by plumage characteristics; age of females is difficult to determine.—J. T. T.

PRIGOGINE, A. 1954. Un nouveau Bulbul de l'Est du Congo Belge. Rev. Zool. Bot. Afr., **49**: 347–349.—*Chlorocichla laetissima schoutedeni* new subspecies, Mt. Kabobo, 29° 2′ E., 5° 8′ S., Belgian Congo.

PRIGOGINE, A. 1955. *Hyliota affinis* Reichenow est bien la femelle de *Hyliota violacea* Verreaux. Rev. Zool. Bot. Afr., **51**: 223–228.

PRIGOGINE, A. 1955. Une nouvelle Fauvette du genre *Apalis* du Congo Belge. Rev. Zool. Bot. Afr., **51**: 240–242.—*Apalis kaboboensis*, new species, Mt. Kabobo, 29° 2′ E., 5° 8′ S., Belgian Congo.

STALLCUP, W. B. 1954. Myology and serology of the avian Family Fringillidae, a taxonomic study. Univ. Kansas Publ., Mus. Nat. Hist., **8**: 157–211, 23 figs.—Original contributions on serology and on the myology of the leg are considered, along with studies by others, in determining the relationships of the finch-like birds. The richmondenines, emberizines, and tanagers are considered closely related and are made subfamilies of the Fringillidae; the Estrildinae and the Carduelinae are placed in a Family Carduelidae; none of these groups is considered close to the Passerinae. *Spiza* is considered an aberrant richmondenine.—R. W. S.

SUTTON, G. M. 1955. A new race of Olivaceous Woodcreeper from Mexico. Wilson Bull., **67**: 209–211.—*Sittasomus griseicapillus harrisoni*, new subsp., from Rancho del Cielo, Gomez Farias, Tamaulipas, Mexico, elevation 3300 feet.

WOOLFENDEN, G. E. 1955. Spring molt of the Harris Sparrow [*Zonotrichia querula*]. Wilson Bull., **67**: 212–213.

MISCELLANEOUS

AXTELL, H. H. 1955. Authorities make too many mistakes. Kingbird, **5** (2): 37–39.—Apparently *all* field ornithologists make frequent errors in sight identification of which they often remain unaware. There should exist "a popular recognition of the unreliability of sight records as usually compiled, and . . . a desire for greater reliability, with an increased interest in adopting scientific methods of verification." Complete written records of important observations should be filed permanently in a known place where they are available to other workers. This paper deserves reprinting in other periodicals.—D. A. Z.

GUIGUET, C. J., and F. L. BEEBE. 1954. The birds of British Columbia, (1) the woodpeckers, (2) the crows and their allies. (Victoria. B. C. Provincial Mus. Dept. of Education Handbook No. 6) 51 pp. 50 cents.—Brief popular accounts and drawings of 12 woodpeckers and 7 corvids.—D. A. Z.

HILL, W. P. 1956. Birds between the monadnocks. (Transcript Printing Co., Peterborough, N. H.) 72 pp. Price, $1.00.—This "field guide," designed for use in southwestern New Hampshire, presents sketchy information on field-marks, local distribution, status, and habitat.—D. A. Z.

MILLER, L. 1955. The auxiliary barrel. Wilson Bull., **67**: 297–301, 1 fig., 2 tables.—Directions are given for making auxiliary barrels to adapt shotguns for collecting small specimens.

SAWYER, E. J. 1955. Bird houses, baths, and feeding shelters, how to make and where to place them. (Bloomfield Hills, Mich. Cranbrook Inst. Sci. Bull. No. 1, 5th edition.) 36 pp. 50 cents.

NOTES AND NEWS

At the banquet of the North American Wild Life Conference in New Orleans, on March 6, 1956, Hoyes Lloyd was presented the Aldo Leopold Award for outstanding contributions to the cause of wildlife conservation in North America.

MARCIA B. TUCKER AWARD IN ORNITHOLOGY

The sum of $550 is available this year in the Marcia B. Tucker Award in Ornithology. These funds are to be used to assist promising young ornithologists in attending the annual meeting of the American Ornithologists' Union at Denver. We expect that awards will be granted to three or more people. The amount in each instance will depend upon the distance to be traveled.

Any member may nominate people for this award. Nominees need not be members, but it is hoped that they may intend to present papers at the meeting. Information should include the following items:

1. Name, age, and address of nominee.
2. Education and experience of nominee.
3. Statement by the sponsor about the capabilities, special interests, and financial need of the nominee.

This information should be sent to the Secretary (Harold Mayfield, River Road, Waterville, Ohio) not later than July 1, 1956. The officers of the A.O.U. will serve as a committee to name the awardees.

THE FIRST RUSSIAN ORNITHOLOGICAL CONGRESS

The first Russian ornithological congress took place in Leningrad, January 19 to 24, 1956. An interesting account of this congress has been prepared by Guy Mountford, who represented the British Ornithologists' Union and the British Trust for Ornithology, and will be published in 'The Ibis.'

STUDENT MEMBERSHIP AWARDS FOR 1956 SELECTED BY THE A.O.U COMMITTEE ON STUDENT MEMBERSHIP AWARDS

Claude T. Adams, University of Florida, Gainesville
John Robinson Cartwright, Queen's University, Kingston, Ontario
Peter Wright Davis, Bowdoin College, Brunswick, Maine
Jared Mason Diamond, Harvard College, Cambridge, Mass.
Elwood Elder Eakin, Wooster College, Wooster, Ohio
Harry Richard Fevold, Montana State University, Missoula
Norman Lee Ford, University of Kansas, Lawrence
William Gordon George, University of Arizona, Tucson
Albert Earl Gilbert, Steinmetz High School, Chicago, Illinois
Stephen Thomas Harty, Cleveland Institute of Art, Cleveland, Ohio
Norman Calvin Higgins, Central Missouri State College, Warrensburg, Missouri
Mary Ann Joyner, Florida State University, Tallahassee
Lloyd Burrows Keith, University of Wisconsin, Madison
Harry Charles Laum, University of Wyoming, Laramie
Halsey Means Marsden, University of Missouri, Columbia
Edward Gordon McCoy, North Carolina State College, Raleigh
John J. McCoy, University of Florida, Gainesville
Barid Baran Mukherjee, Brigham Young University, Provo, Utah
John Carl Oberheu, Southern Illinois University, Carbondale
Donald W. Simkin, Ontario Agricultural College, Guelph
Alan Ernest Stiven, University of New Brunswick, Fredericton
Robert D. Weigel, University of Florida, Gainesville
James Russell Werner, Phoenix College, Arizona
Clayton M. White, University of Utah, Salt Lake City

OBITUARIES

WARDER CLYDE ALLEE, a Member of the American Ornithologists' Union, elected in 1940, died in Florida on March 18, 1955. He was born in Bloomingdale, Indiana, June 5, 1885. Following the receipt of a B.S. degree at Earlham College, he took graduate work at the University of Chicago, where his Ph.D. was granted in 1912. Teaching positions were held at the Universities of Illinois and Oklahoma, and Williams and Lake Forest colleges. In 1921, he returned to the University of Chicago as Assistant Professor of Zoology. He became Professor in 1928 and held this position until his retirement in 1950. He then served as Chairman of the Department of Biology, University of Florida, until his death. During the last 25 years of his life, due to paralysis, he was confined to a wheel-chair.

He served as President of the Ecological Society of America (1929), President of the American Society of Zoologists (1936), and Vice-President (Section F) of the A.A.A.S. (1942). He was also a member of the American Society of Naturalists, Entomological Society of America, and a corresponding member of the Philadelphia Academy of Sciences. He was a member of the board of trustees of Earlham College for several years and was given an honorary Ph.D. by this institution in 1940.

His researches dealt mainly with animal ecology and behavior, and the sociology and physiology of populations. Aside from numerous papers in journals, he was co-author of: 'Principles of Animal Ecology'; 'The Social Life of Animals'; 'Animal Aggregations'; and 'Ecological Animal Geography.'—A. W. SCHORGER.

CHARLES JAMES RHOADS, a life member of the American Ornithologists' Union, elected in 1895, died in Bryn Mawr, Pennsylvania, January 2, 1956. He was born in Germantown, Pa., October 4, 1872. After attending the William Penn Charter School, he entered Haverford College and graduated from that institution in 1893. He held numerous civic and business posts, among which may be mentioned: Vice-president of the Girard Trust Company (1904–14); Governor of the Federal Reserve Bank of Philadelphia (1914–18); President of the Central National Bank, Philadelphia (1920); Commissioner of Indian Affairs (1929–33); Chief of the American Friends Service Committee, American Red Cross, World War I; member of the Board of Managers, Haverford College; and President of the Board of Trustees, Bryn Mawr College. Memberships were held in the American Academy of Political and Social Sciences, Historical Society of Pennsylvania, and American Philosophical Society.

He was a member, since 1890, and past President of the Delaware Valley Ornithological Club. His cousin, Samuel N. Rhoads, was one of the founders of the club. The ornithological publications of Charles James were limited to local notes and data on migration contributed to 'Cassinia.'—A. W. SCHORGER.

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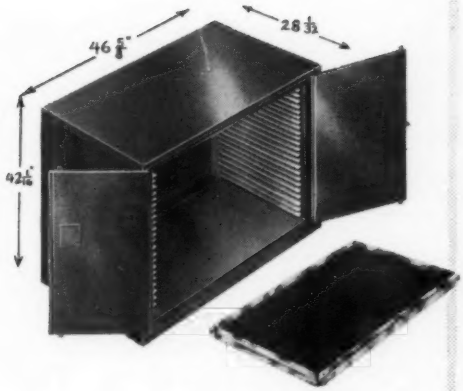

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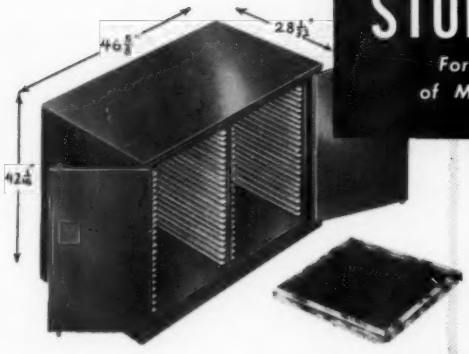

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